Digitized by the Internet Archive
in 2010 with funding from
University of Toronto

http://www.archive.org/details/chemicalengineer05newy

ELECTROCHEMICAL AND METALLURGICAL INDUSTRY

(With which is Incorporated The Iron and Steel Magazine)

A Monthly Journal of Electrochemistry and Metallurgy

VOLUME V

From January to December 1907

436830
3. 7. 45

NEW YORK:
ELECTROCHEMICAL PUBLISHING CO.

INDEX TO VOLUME V.

GENERAL ALPHABETICAL INDEX.

Articles of Electrochemical Interest are indicated by S, from the Analysts of Current Electrochemical Patents by A; from the Electrochemical Patents issued July, 1902, by D; from Recent Metallurgical Patents by M. Illustrated articles are indicated by *.

A

ALBE Engineering Co ..286, 422, 4..9
Accumulators. (See Storage Battery.)
Acetylene brook and tube 473
Acker Process Co 69, 106
Adams recorder 107
Adamson Patten 225
Air Liquid *426
Alkali Agency, Koch (A.) 416
Alkaline sterilizing Dorn. (A.). 416
Alkaline Mettler (A.) 239
Allis-Chalmers Co ..*34, 101, 306, 473, 474
Alloys Research 234
— By electrolysis from fused salts. Kruger and Seward. (A.) . 411
— See also the different metals, also Furnace, Electric. Manufacture of Ferro-Alloys.)
Aluminium substances Treatment. Desgeorge (A.) 379
Alternating current Physiological effect Nernst and Reiss (S.) 466
Alternating Four-year run General Electric Co *24
Aluminium
— Aluminium Corporation, Ltd 416
— Alloys with copper (S.) 100
— Alloy Chamberlain (S.) 286
— Alloy Fletcher (M.) 426
— Carbide Decomposition. (S.) 31
— in Italy 105, 294
— Plant in Kentucky 106
— Price reduction 513
— Progress in 1902. Richard 282
— Reduction of boric anhydride and silica 489
— Removal of sodium from sodium-aluminium alloys. Roberts (M.) 281
— Solder. Fuss (M.) 379
— Soldering. Hall (A.) 196
— Specific properties. Hammer 231
— Sulphate 515
Ammeter, portable, compound *267
American Association Advancement of Science 35
American Electric Co 69
American Electrochemical Society 198, 289
American Chemical Society. Electrochemical meeting 257
American Electric Furnace Co ..... 2.., 33
American Electrochemical Society 35, 41, 101, 125, 159, 162, 200, 217, 252, 300, 381, 385, 429, 465, 479, 490, 515
— New York meeting, report *441
— Philadelphia section *217
— New York section 65, 100
— Philadelphia section 106
— Presidency 450
American Ferro-fix Brazing Co 69
— Electrochemical Association 63, 216, 515
American Gas & Electric Co 235
American Graphite Kleiln Co 151, 479
American Institute of Mining Engineers 118
— meeting 30
American Institute of Social Service ..37, 241
American Investment Co 66, 246
American Museum of Security 37, 244
— Steel Association 429
American Society for Testing Materials.. 256
American Spiral Pipe Works 305
American Vanadium Co 494
Ammonia, nitric acid. Patten. 449
— Synthesis of. Nernst 457
Analysis:
— Apparatus and electrode. Guess and Haultain. (A.) 506
— Determination of iron. Van Arsdale. (S.) 99
— Electrolytic. (S.) 465
— Electrolytic Smith 219
— Electrolytic assaying 197
— Gas. Barnhart *300
— Philipp 440
— Minute quantities of copper. Free ... *449
— Ore-testing crucible for assayers. Hunsinger. (A.) 473
— Pouring mold for assayers. Bailey.... *242
— Silicon. Albro and Mott.... 445
— Silver bullion 94
— Clennell. (S.) 147
— Vanadate of iron. Wilson 496
Antimony and arsenic ores. Herrenschmidt process. (S.) 32
Argon with calcium cyanamide. (S.).. 465
Aromatic alcohols. Mettler. (A.)..... 239
Arsenic. Alloys with iron. Friedrich. (S.) 194
— and antimony ores. Herrenschmidt process. (S.) 32
— compounds of lead. Vreeland. (A.).. 516
— Nickel-arsenic alloys. Friedrich and Bennigson. (S.) 423
Assaying (See Analysis.)
Atomic weights. Branner, Bernoulli... 457
Atoms Disintegration of. Voller, Marckwald, Meyer, Lerch, Hahn, Levin, Tammann 456

B

BALANCE. Voland & Sons. *68
Ball filling for sulphuric acid towers..... 151
Batteries. (See Storage Battery, Primary Battery.)
Berthelot 113
— By Doremus *382
Bertuch, Fred, & Co. 107, 151
Bessemer converter (See Converter.)
Bichromates. Electrolytic Suchy. (A.). 32
Blitzer, J 19
Bismuth Refining. Mohn *314
Blackwell, Geo. G. Sons & Co 69
Blast (See also Furnace, Metallurgical.)
— Dry blast at Pottstown 290
— Gayley dry-blast. Nagel 292
— Hot Blast. Munson. (M.) 195
— Hot blast stoves. Lurmann. (S.) 281
Blasting machine Bowman. (A.)..... * 420
Blowing cotton Vogelsang. (A.)..... 471
— flour. Alsop 366
— liquor. (See Sodium chloride. Electrolysis.)
— powder. (See Sodium chloride. Electrolysis.)
Blowing engines Turbo. (S.)..... 32
Blowpipes (See Welding and Cutting.)
Boiling points of metals. Watts..... 470

Book Reviews:
— Alternating-Current Motors. By A. S. McAllister 337
— Annuaire Universel des Mines et de la Metallurgie. By R. Pitaval..... 518
— Chemistry and Technology of Mixed Paints. By Maximilian Toch..... 111
— Commercial Organic Analysis. By Alfred H. Allen 337
— Contributions to Economic Geology, 1900, Part I. By C. F. Emmons and E. C. Eckels 384
— Conversations on Chemistry. By W. Ostwald, Elizabeth C. Ramsay and Stuart K. Turnbull..... 156
— Copper Mines of the World. By Walter Harvey Weed 383
— Corrosion and Protection of Metals. By A. Humboldt Sexton..... 155
— Department of Commerce and Labor, Bureau of the Census. Census Bulletins 482
— Deutsches Patentrecht für Chemiker. Julius Ephraim 252
— Dredging for Gold in California. By D'Arcy Weatherbe 431
— Electric and Magnetic Measurements and Measuring Instruments. By Frank W. Roller.....
— Electro-analysis. By Edgar F. Smith.
— Electrochemistry—I. By H. Danneel and Edmund S. Merriam.....
— Electrochemistry of Organic Compounds. By Walter Lob and H. W. F. Lorenz 482
— Elektrochemische Deutsche Reichspatente. By F. Ferchland and P. Rehländer 111
— Elektrolyse Geschmolzener Salze. By Richard Lorenz 109
— Elektrolytische Alkalichloridzerlegung mit flüssigem Metallkathoden. By R. Lucion 110
— Elektrolytische Chloratindustrie. By John B. C. Kershaw and Max Huth 109
— Electrolytische Verzinkung. By Sherard Cowper-Coles and Emil Abel. 109
— Elektrometallurgie des Eisens. By Bernard Neumann 251
— Elements of Chemical Engineering. By J. Grassmann 433
— Family Motor Tour Through Europe. By Leo H. Balkeland 520
— Fire Assay of Gold, Silver and Lead in Ores and Metallurgical Products. By L. S. Austin 432
— Fire Assaying. By Evans W. Buskett. 249
— Foods and Their Adulterations. By H. W. Wiley 519
— Gypsum and Gypsum Products in 1906. By Ernest F. Burchard..... 385
— Handbook of Mathematics. By J. Claudel and Otis A. Kenyon..... 158
— Handbook of Metallurgy. By Carl Schnabel and Henry Louis..... 155
— Harper's Electricity Book for Boys. By Joseph H. Adams 519
— Hydrometallurgy of Silver. By Ottokar Hofmann 249
— Introduction to Metallurgical Chemistry for Technical Students. By J. H. Stansbie 518
— Investigation of the Borides and the Silicides. By Oliver P. Watts..... 338
— Laboratoriumsbuch für den Eisenhütten Chemiker. By Max Orthey.... 385
— Labratory Guide of Qualitative Analysis. By E. H. S. Bailey and H. P. Cody 34
— Lead Smelting and Refining. By W. R. Ingalls 110
— Lehrbuch der Elektrochemie. By Max Le Blanc 157

—Lehrbuch der Organischen Chemie. By Wm. A. Noyes and Walter Ostwald 517
—Manufacture of Metallic Articles Electrolytically—Electro-Engraving. By W. Pfanhauser and Joseph W. Richards 252
—Merck's 1907 Index. Third edition.... 434
—Metall-Analyse auf Electrochemischem Wege. By A. Hallard, L. Bertiaux and F. Warschauer 383
—Metallurgical Calculations, Part II. By Joseph W. Richards..... 294
—Monographs on Applied Electrochemistry.....109, 110, 111, 251, 252, 482
Open-Hearth Steel Castings. By W. M. Carr 386, 432
—Populäre Schriften. By Ludwig Boltzmann 495
—Proceedings of the Chemical, Metallurgical and Mining Society of South Africa 200
—Producer Gas. By J. E. Dowson and A. T. Sarter 66
—Production of Aluminium and Its Industrial Use. By Adolphe Minet and Leonard Waldo 201
—Principles of Copper Smelting. By Edward D. Peters 199
—Radioactive Transformations. By E. Rutherford 112
—Recent Development of Physical Science. By Wm. Cecil D. Whetham 202
—Report on the Experiments Made at Sault Ste. Marie. By Eugene Haanel 250
—Some Founders of the Chemical Industry. By J. Fenwick Allen..... 158
—Table of Volumes Through Airways. By C. H. Kuderer 294
—Text Book of Electrochemistry. By Max Le Blanc, Willis R. Whitney and John W. Brown 295
—Text Book of Elementary Analytical Chemistry. By John H. Long.... 250
—The Mineral Industry During 1906. Edited by W. R. Ingalls..... 431
—Transactions of the American Electrochemical Society. Vol. XI..... 484
—Transactions of the Faraday Society. Vol. III., Part I..... 385
—Uber die Elektrolytische Gewinnung von Brom und Jod. By Max Schloetter 482
—Uber Ferrosilicium. By W. Pick..... 340
—Van Nostrand's Chemical Annual, 1907. By John C. Olsen 110
—Vellcome's Photographic Exposure Record and Diary, 1907..... 252
—ic anhydride reduced by aluminium. Westen and Ellis 489
—ron. Reduction, Kuhe. (M.)..... 330
—in steel. Guillet. (S.) 421
—Boron carbide. Tucker. (A.)..... *469
Brass. Buttenshaw. (M.) 242
—Electrolytic corrosion. Lincoln..... 228
—welding with epurite 288
Brick. Acid-proof 473
—Refractories 152, 335
—sand-lime 303, 516
Bristol, Wm. H. 289, 477
British Aluminium Co., Ltd..... 276
Bronze substitute. Ruebel. (M.)..... 380
Brown & Son, Edward.....69, 380
Buffalo Dental Mfg. Co.....107, 154
Bunsen Society 292
—Hamburg meeting 456
Burgess, C. F. *217
Burner for cutting metals. Schoop..... *308
—. (See also Welding.)

C

CABLES. Drying. Hale. (A.) 240
CALCIUM:
— Manufacture of. (S.).....414, 467
— Escard 283
—as reducing agent. Perkin..... 276
—for thermit. Goldschmidt 283
— Alloy with magnesium. (A.) 414
— Alloy with zinc. Kügelgen and Seward. (A.) 279
— Calcium chloride from pickling iron, for paint 395
Calcium nitrate as fertilizer..... 375

CALCIUM CARBIDE:
— Manufacture Hartenstein (A.) 102
— Willson. (D.) 154
— Whitehead, Dickerson, Clarke, Boehm. (D.) 198
— Willson, Clarke. (D.)..... 248
— King, Wyatt, Willson. (D.) 292
— Eldridge, Hewes, Whitney, Morehead, Roberts. (D.) 326
— Petersson. (A.) *377, 378
— Roberts, Blum, Clark, Heath, Fahrney, Cowles. (D.)..... 382
— Morehead. (A.) *412
— Hartenstein, Hewes. (D.) 430
— Hewes, Wilson. (D.) 480
— Wilson, Wood, Roberts. (D.) 516
— Decomposition. (S.) 31
— in Ireland 290
— Ferro-calcium carbide. Misko. (A.).. 470

CALCIUM CYANAMIDE:
— General..... 72, 198, 289, 374, 479
— Carlson. (S.) 98
—Erlwein 59, *77
—Foerster and Jacobi..... 461
—Bredig 465
— Argon. (S.) 465
Calculations. Metallurgical. Browne... *174
— Richards....11, 44, 79, 129, 165, 212, 266, 304 332, 398, 458, 496
Canadian Mining Institute. Toronto meeting 117
Carbides. Decomposition by reagents. (S.) 31
—(See also Calcium carbide and the other carbides.)

CARBON:
—in electrometallurgy. FitzGerald and Forssell 229
—crucible. Mueller. (S.)..... 466
—for resistors. Rivers. (A.)..... 55
— granular. Tucker, Doty, Canchois. 450
— graphitized. Girard and Street..... 236
— Carbon electrodes. Joint. Tone. (A.). 378
— Möllenbruck and Dielmann.. (A.) 505
— Shorts. (A.) 141
—Stubbs. (A.) *471
— Heat conductivity. FitzGerald..... 451
— Carbon dioxide indicator..... 335
—Carbon dioxide recorder 107
— Carbon tatrachloride 69
— Crocker *250
— Maywald. (A.) 501

CARBORUNDUM:
—Manufacture. Acheson. (D.) 36
— Acheson, FitzGerald. (D.)..... 70
— Acheson, Parks, Hunt, Talbot, Engels. (D.) 108
— Decomposition. (S.)..... 31
—as reducing agent. Becket. (A.)..... 222
Card index 41
Castings cleaned by sand-blast..... 334
Castner-Kellner Alkali Co., Ltd..... 27
Cathode for mercuric salt solutions. Hatfield. (A.) 327
Caustic. (See Sodium chloride. Electrolysis. Caustic and chlorine.)
Cell. (See also Batteries and Tank.)
—Diaphragh. Betts. (A.)..... *239
— Electrolytic. Gravity-Diaphragm cell. Rambaldini. (A.)..... 415
— with three compartments. Findlay (A.) 194
— (See also the different manufactures. For instance, Sodium chloride. Electrolysis.)
Celluloid substitutes Desgeorge. (A.)... 379
Cement. Machinery 154
—Zinc dust in 248
Chandler, C. F. *49
Charcoal ovens. Juon. (S.)..... 283
Chemists' Building 74
Chlorates. (See Sodium chloride. Electrolysis. Chlorates.)
Chlorine in metallurgy. Baker..... 448
—(See also the different metals and Sodium chloride electrolysis.)
Christy Fire-Clay Co..... 335
Clark Electric & Mfg. Co..... 197
Clay products 430
Coal. Calculating calorific value. Gontal. (S.)..... 145
— Charcoal ovens. Juon. (S.)..... 283
— Coking of. Keighley. (S.)..... 376
Cobalt. Copper, nickel cobalt from sulphides or arsenides. Ryan. (A.).. *356
— nickel arsenides. Baker..... 448
— Roasting argentiferous cobalt-nickel arsenides. (S.)..... 147
— Treatment of nickel-copper-cobalt-iron ores. Mac Ivor. (M.)..... 329
Cocks. Stoneware *290
Coke. Coking of coals. Keighley. (S.). 376
— Determination of quality. Thare (S.) 243
— Formation of Prussian blue in the ammonium sulphate from coke-oven by-products. (S.) 243
Colloids. Kuzel. (M.) 500
— Practical applications 436
Colorado College..... 108, 336, 479
Colorado Iron Works Co. 165, 334, 381, 430
Colorado School of Mines 291
Columbia University 429
Combination meter *287
Combustion and dissociation 242
Compressibility of elements. Richards. 457
Concentration cells. Carhart and Mellencamp 451
Concentration changes and migration velocities. Reed 218

CONCENTRATION AND SEPARATION:
— Acid flotation process. Jackson. (S.). 329
— Colorado Iron Works Co. 334
— Electrostatic Esser. (S.) 468
— Magnetic Lyon Mountain 473
— Blomeke. (S.) 30
— Grondal, Bennie *134, 479
— Wait, (A.) *419
Concilium Bibliographicum 41
Conduction. Electric. Steinmetz 221
Conductivity. Dilute solutions. (S.)..... 467
— of solutions. Effect of suspended particles. Patten 258
— Electric of metals. Theory 189
— of electrolytes. Determining without electrodes. Franklin. (S.) 467
— of fused salts. Arndt 457

CONVERTER:
—Copper. Hydraulic. Shipley *474
— Copper. Electric. Shipley *244
— Campbell. (M.)..... *96
— Eldred. (M.)..... 96
—Temperature increment in Bessemer converter. Richards..... 11
— (See also Copper, Iron and Steel.)

COPPER:
— Advances in smelting. Gowland..... 277
—Alloys with aluminium. (S.)..... 101
—Alloys with phosphorus. Heyn and Bauer. (S.) 282
— Alloys with silver and lead. Friedrich and Leroux. (S.)..... 283
—Alloys with zinc. Battenshaw. (M.). 242
— Anode in chloride solutions..... 258
— Bessemerizing matte. Hamilton. (M.) 33
— Lloyd. (M.)..... *327
— Richards 356
—Bringing forward of copper matte. Richards 352
— Bronze. Ruebel. (M.) 380
— Chlorination. Process 448
— Froelich. (M.) 149
— Constitution of ferro-cuprous sulphides. (S.) 148
— Copper-silicon. Philipps. (S.) 468
— Copper-steels. Brenil 312
— Cost and price 160
— Desulphurizing ores. McMurty-Rogers 277
— Determination of minute quantities. Free *449
— Diaphragm cell for sulphate electrolysis. Betts *238
— Electric converter. Shipley..... *244
— Electric smelting. Richards 496
— Electrolysis from ores. Lamb. (A.).. 415
— Jumean. (S.) 470
— at Medzianka. (S.) 421
— Electrolytic deposition. Harrison and Day. (A.) *416
— Electrometallurgy. Richards 496
— Flux for welding. Wilson. (M.)..... 149
— From sulphides. Anderson. (A.)..... *415
— Baker and Burwell. (A.)..... 56
— Packard. (A.) *57
— or arsenides. Ryan. (A.)..... *56
— German silver. Hobson. (M.)..... 150
— Hardening. Anderson. (M.) 196
— Hendryx process 430
— Hot-blast pyrite smelting. Munson. (M.) *196
— Hydraulic converter. Shipley..... *474
— Magnesium for copper sand castings. (S.) 147
—Overfire in copper matting blast-furnace practice. (S.)..... 101
— Power & Mining Machinery Co..... 430
— Precipitation from sulphates. Puman. (M.) 507
— Pyritic smelting. Baggaley. (M.).... 425
— Richards 374
— Stichi. (S.).....31 (S.), 59, 302
— Use of electrically-heated air. Arden. (M.) 328
— Refining. Betts (A.) 327
— Richards 458
— Australia 248, 480
— Schwarz. (A.) 103
— Removing iron. Roberts. (M.)..... 284
— Roasting and smelting ore. Richards. 212
— Slimes from dressing copper sulphide ores Thomson and Laist. (M.)... 33
— Smelting. Richards 266
— Smelting and converting Day. (M.). *506
— Smelting furnace Kemp. (M.)..... 328
— Treatment of low-grade ores. Haraldson. (M.) 506
— Treatment of low-grade matte. Lott's. (M.) 149
— Treatment of nickel-copper-cobalt-iron ores. MacIvor. (M.) 329
— Treatment of silicates. Waterbury. (M.) 149
— Wallaroo Smelting Works 27
— Welding with epurite 288
— Copper and Brass'. 153
Corrosion. Brasses. Lincoln 228
—Iron. Cushman. Walker...224, 254, 257, 270 343, 363, 364
Cotton. Yarn, electrically singed 291
Coulometer. Silver Duschak and Halett 451
Crocker-Wheeler Co. 36, 198, 281
Cupola linings 107, 152
Cutting metals. Jottrand and Buys (M.) 426
— Schoop *308
— 381, 420
Cyanamide. (See Calcium cyanamide.)
Cyanide Process. (See Gold.)

D

DUCKER [illegible] Mfg. Co. 231
[illegible] Graphite Acheson *452
Deville-Edwards 381, 429
Department of Mines, Canada 291
Deutsche Kalk 455, 466
Dewar 58, 142, 376
[illegible] 238
[illegible] (A.) 194
(See also Sodium chloride. Electrolysis.)

Dissociation, Electrolytic:
Experiments supporting theory 33, 72
77, 147, 278, 312, 338, 418, 462, 465, 479, 491
theories 236, 284, 287, 319, 419, 545
Solutions, see Kitsee. (A.) 472
Distillation 342
Distillation of alloys. Mussan (S.) 38
Drying cylinders. Hale. (A.) 240

E

Edison CATHION Technical 37, 389, 437
Electric electrolytic cells. Mett... 218
Elmer & Amend 291
Electric conduction. Steinmetz 221
Electric Cable Co. 236
Electrochemical problems. 41, 92
Electrodes of carbon. 141, 142, 378, 451, 471, 507
Electric analysis. (See Analysis.)
Electricity and electron theory 72, 94
Electrolysis at low temperatures. Steele 480
Electro Metallurgical Co. 69, 248
Electroplating. (See Plating.)
Electroquartz 107
Electrotyping. Gerstner. (A.) 32
Elements, transmutation of. Ramsay.... 311
Engelhard, Charles 335
Engineering Conference, London..... 317
Engineering Exhibition, London..... 502
Engineering Rule of Thumb versus. Richards 4
Engineering Society Building..... 118
Esurite process 288
Equations, Symbolism of chemical... 249
Essing & Co., Hermann 429, 479
Evaporator, Kestner 231

F

FANS 69
Hard lead exhaust *333
Faraday Society..7, 26, 52, 54, 125, 236, 276, 374, 489
Fassett, C. M. 198
Feldspath. Extracting potash. Cushman. (A.) 280
Ferroalloys 9, 248, 378, 412, 429, 512
Ferro-aluminum 429, 513
Ferro-calcium carbide. Misko. (A.)... 470
Ferro-chrome. Haught 513
Ferro-manganese. Haughton 512
Ferro-molybdenum. Annable (M.) 241
Ferro-silicide. Wilson. (A.)..... 140
Ferro-phosphorus 107, 513
Ferro-silicon 97, 278, 321, 513
Ferro-titanium 69, 511, 513
Fertilizers from air. See Nitrogen. Fixation and.
Fibers. See Gold.
Filter process for slimes. Wm. R. Perrin & Co. *67
Filter Bargin 140
Butters *88, 243, 282, 329
Dav... 328
Hendrye 508
Denver and Herb... 329
Kelly and Costello 508
Merrie 243
Stewart 508
[illegible] 325
[illegible] 154
[illegible] Precipitate De Hemptinne (A.) 241
[illegible] Stones (See Concentrator.)
[illegible] 382
Furnace Gases, Recovery of Fats and Metals from (A.) 505
Furnace Operations in metallurgical calculations. Greene *174
Furter Miller Engineering Co. 69
Furnaces, Electric smelting 37, 42, 75, 247
Fire-clays 97, 512
Fused Electrolytes. Society Proposed 292

FURNACES, ELECTRIC:
General Construction and Operation:
Carbon crucible. Mueller (S.) 466
Carbon electrodes. 141, 142, 378, 451, 471, 507
Dummy electrode. Heroult. (A.) *504
Carbon uses. FitzGerald and Fassell 289
Charging. Huffmann (A.) 324
Casting electrodes. Becket. (A.). 279
Dental furnace. Roach. (A.)..... 22
Detachable hearth. Price (A.) 322
Electric versus fuel heat..... 298
Fused quartz receptacle. Bristol. (A.) *55
Heating bar. Brougham. (A.) *413
High-pressure reactions. Hutton Peavel. (S.) 242
Increasing the temperature of molten materials by electric heating. Wynne. (Ni)..... 194
Induction furnace..25, *92, 118, *151, *172 335, 480
Colby. *55, *321
Ferranti. (S.) 375
Harden. 25, 324
Mathematics. Gin 446
Induction shaft furnace. Edstrom. (A.) 414
Pinch phenomenon as limitation of resistance furnaces. Hering.... *223
pyritic smelting. Arden 323
Resistor Tone (A.)..... 501
Boelling. (A.) 412
Oxides. Saklatwalla. (S.) 463
Egly 413
Rivers 55
Tucker. Granular carbon...227, 470
Tucker. Platinum for melting points 258
Stuffing box for electrodes. Heroult. (A.) 504
Tube furnace. Féry Lanelet 292
for temperature measurements. Tucker *227
Various designs:
Bristol. 55, *477
Clark. (A.) 414
Collens. (A.)..... *56
Dion. (A.) 56
Heroult. (A.) 325
Higgins. (A.)..... 323
Ischewsky. (A.) *141
Hoskins Co. Muffle *428
Marsh. (A.) Muffle *413
Peters. (A.) *377
Potter. (A.) 414
Robertson. (A.) 415
Stevens. (A.) 141
Young. (A.) 411

MANUFACTURE OF:
Boron carbide *469
Calcium carbide..102, 154, 198, 248, 290 292, 336, 373, 378, 382, 412, 430, 480, 516
Calcium cyanamide .*77, 198, 374, 461, 465
Carbon graphitized 236
Caruorundum 36, 70, 168
Chromium 237
Copper 496
Ferroalloys..237, 248, 278, 321, 322, 378, 412
Ferro-calcium carbide 470
Glass. Clark. (A.) 414
Iron and steel 36
Annealing and hardening..... 428
From black sands. Day and Richards 85
Blount 265, 372
Colby and Kjellin....25, *55, 92, 118, *151, *172, *232, *321, 335, 446, 480 375
Edstrom 411
Evans 25
Foundry 37
Bennie 75
Meidenke 42, 296
Gin. Titaniferous iron ores.... 226
Girod *9
Greene and MacGregor..... *367, 445
Harden 25, 324
Heroult. Pig iron....8, 291, 298, 318 411
Heroult. Steel..25, 58, 153, 198, 279, 411
Hiorth. (S.) 375
Hutton 24
Lash. (A.) 279, 322, 378, 440, 455, 479
Noble Electric Steel Co..8, 291, 298 318
Richards 165, 446
Roechling. 25, *92, *172
Russell. Model exhibition... 233
Manganese silicide 412
Molybdenum 322
Monox *444
Nickel-silicide and Ferro-nickel silicide 140
Nitric acid and nitrates. (See Nitrogen. Fixation of.)
Phosphorus..... *55, 378, 407, 412
pottery 94
Silicides and silicon alloys..... *141
Silicon monoxide *441
Silicospiegel 322
Uranium 322
Tungsten 237, 322
Vanadium 322, 412
Zinc..83, 103, 228, 265, 323, 373, 446, 470 489

FURNACE, METALLURGICAL:
Blast Furnace.
Charge handling in the Southwest. Brinsmade. (S.) 62
Charging apparatus for blast furnace. Johnson. (M.) 328
Dry blast 290, 302
Hot blast. Munson. (M.).. 196
stoves. Lürmann. (S.) 281
Economic distribution of power from. Thwaite 394
Gases. (See Gas.)
top construction..... *120, 328
Tuyeres. MacDonald. (M.) 328
Converter, Bessenier. By Richards.... *11
plant. Campbell. (M.) *96
process. Eldred. (M.) 96
Copper. Electric *244
Copper. Hydraulic *474
Open-hearth. Richards 44, 79, 129
Coal and oil, muffle. Young..... 321
Furnace doors. Cromwell. (M.)..... 508
McDougall roaster. Kliepetko. (M.).. 98
Melting furnace. Schwartz. (M.)..... *508
Producer-gas-fired muffle-furnace. Nagle *398
Reduction without smelting. Jones. (M.) 509
Removal of zinc sulphide accretions in reverberatory forehearths 40
Reverberatory furnace fired by producer gas. Nagle *360
Turbine furnace. De Laval. (M.). *241, 424
Furnace, Metallurgical. (See also the different meals.)
Fused salts. Conductivity. Arndt 457
Electrolysis. Lorenz 465

G

GALVANIZING. (See Plating.)

Gas:
analysis. Barnhart *350
Philip 440
blast furnace gases. Power..... 248
Ruthenburg 31
Calorific value. Ehrenwerth..... 394
engines for water gas. (S.)..... 510
Large gas engines 502
Nürnberg gas engines..... 299
Fischer gas valve 290
power 220, 291, 248
producers 68, 69, 344
producer gas for muffle-furnaces. Nagel *398
in chemical industries. Nagel..... *360
from peat 406
Steam in gas producer practice. Bone and Wheeler 263, 316
Volume determination. Starch. (S.). 281
Water gas 19, 41, 510
Luminosity of gases. Thatcher..... 184
German Bunsen Society. Hamburg meeting 456
German silver. Habson. (M.) 150
General Electric Co..... 36, 247, 291, 470
General Storage Battery Co..... 154, 514
Generators for refineries 381
Glass sand 291
Glycolic acid. Liebknecht. (A.)..... 415

GOLD:
Ancient mining in Egypt..... 422
Assaying. Claudet 51
Auriferous ore containing insoluble arsenides. (S.) 193
Chlorination. Grenawalt. (M.) 97
Lander. (M.) 65
Chlorination barrel. Armbruster. (M.) 329
Chloridizing, roasting. McKnight. (M.) 330
Colloidal silicic acid in slime. Caldecott. (S.) 191
Continuous boiling-out still for ammonia-cyanide process 242
Crushing efficiency of tube mills. (S.) 191
Cyanide process. Goetschins. (M.).. Hall. (A.) 472
Just. (M.) 65
Advance 329
in presence of copper. Anderson. (M.) 425
clean-up. (S.) ..... 28, (S.) 191
Clarifying solutions for precipitation. (S.) 193
Extraction from cyanide. (S.)..... 192
Precipitation. Hendryx ..... *24, Richmond. (S.) 144
Boulder Co. ores. (S.)..... 100
plant. Hunter. (S.) 422
New plant. Lamb. (S.)..... 63
Sand sampling. (S.)..... 29
Treatment of precipitates. (S.)..... 193
Treatment of zinc box precipitates. (S.) 28
Treatment of gold-zinc slimes. (S.) 28
raw pyritic concentrates. Smith. (S.) 146
Density of settled sand. Simpson. (S.) 160
Electrochemistry of. Campbell 276
Extraction from refractory ores. Worsey and Heud. (M.)..... 149
Filter..67, 88, 100, 243, 282, 320, 328, 329, 508
From gold-plate scrap. (S.)..... 468
Grinding in tube mills. (S.)..... 146
Hendryx process 430, 508

—Homestake mills. (S.) 320
—Large tube mills *286
—Loss in placer mining. Storall. (S.). 145
—Milling with Lane mill. Stewart. (S.) 99
—Modern milling 14
—Problems of the Rand..... 371
—Production in 1906 515
—Refining at mint 234
—Removing broken stem ends from stamp heads. (S.) 19
—Roasting furnace. Greenawalt. (M.). 97
—Slime concentrator *107
—Stamp-milling *63, 130
—Tavener process. (S.) 146
—Testing ores in the field. Pritchard. (M.) 425
—Treatment of refractory ores. Wynne and Grant. (M.) 425
—Tube-mill lining. (S.) 101
—Wet crushing and concentration in Western Australia. (Hickes. (S.). 62
—Tube-mill practice. Graham. (S.).... 422
—Tube mills at Guanajuato. (S.)..... 422
—Washing slimes and pulp. Griswold. (M.) 425
Goldschmidt, Hans 480
Goldschmidt Chemical Co. 36
Goldschmidt Thermit Co. 196, 218, 285
Graham, Charles, Chemical Pottery Works 290
Graphic formulæ for metallurgical calculations. Browne *174
Graphite Deflocculated. Acheson.....238, *452

H

HAANEL, Eugene 291
Harbison-Walker Refractories Co..... 152
Hard-lead exhaust fans..... *333
Helion lamp. Parker 230
Helium in ores and minerals. Strutt..... 109
Hendryx Electro Cyanide Co..... 130
Horsepower-, watt-, ammeter combined... *287
Hose, lead-lined *331
Huskins Co. 428
Hydrocarbon oils. Purifying. Neiburg. (A.) 280
Hydrogen potential 236
Hypochlorite. (See Sodium chloride Electrolysis. Hypochlorite.)

I

IMMIGRANTS as imports..... 71
Impact. Resistance of materials to..... 235

Industrial Gas Co. 324
Industrial Oxygen Co..... 288
Institution of Mining and Metallurgy...27, 277
Instruments. Long-scale switchboard..... *246
Insulator clamps 197
Internal combustion engines..... 515

IRON AND STEEL:
—Ageing of mild steel. Stromeyer. 294, 316, 395
—Alloys. With arsenic. Friedrich. (S.) 194
— with zinc. Wologdine. (S.)..... 60
— Constitution of iron-carbon alloys. Le Chatelier. (S.) 60
—Austrian iron industry. Kest anek.... 393
—Basic Bessemer converter. Belman. (S.) 376
—Bessemer steel process 114
—Blast furnace. Growth in 50 years..... 253
— Dry blast 290, 302
— Gases for power. (See Gas.)
— top construction..... *120, 328
—Charging apparatus. Johnson. (M.) . 328
—Boron steel. Guillet. (S.) 421
—Calcium for refining. Misko. (A.)..... 472
—Carbon-tungsten steels. Swindon..... 312
—Case hardening. Scott 395
— mild steel. Bannister and Lambert 396
—Cast iron as cast and heat treated. Hatfield 313
—Cast iron properties. Orthey. (S.)... 429
—Cold galvanizing *331
—Combined Bessemer converter and open-hearth process. (M.)..... 65
—Compound steel. Eyermann *122
—Constitution of ferro-cuprous sulphides. (S.) 148
—Converter plant. Campbell. (M.) ... *96
—Converter process. Eldred. (M.)..... 96
— Richards 11
—Copper-steels. Brenuil. 312
—Corrosion of iron an electrochemical phenomenon. 224, 254, 257, *270, 343, 363, 364
—Cupola practice. Jaeger. (S.)..... 421
—Cutting metals. Taylor. (S.)..... 30
—Cutting by oxy-hydrogen flame. *368, 381, 420, 426
—Cutting tool. Measuring the forces on. Brooks 419
—Determination of iron. Van Arsdale. (S.) 99
—Distribution of sulphur in metal ingot molds. Henderson 312
Electric furnace in iron and steel metallurgy. (See Furnace, Electric; Manufacture of; Iron and Steel.)
Electric power in German iron works. (S.) 469
Electric Power in rolling mills.....335, 503
Electrically-driven reversing rolling mills. Bigge 262
Electrodeposition of iron. Cowper-Coles 291
—Enamelled iron pans.....69, 197, 294
—Erzberg of Eisenerz. Bauerman..... 398
Ferro-alloys. See Ferro-alloys.
—Fines. Treatment. Heberlein (M.). 97
— Lash. (A.) 378
—Fines and flue dust. Briquetting.... 479
— Bergendal. (M.) 65
— Grondal. Bennie *184
— Robeson. (M.) 96
— Schumacher 328, 379, 424
— Scott. (M.) 506
Flange union 335
Flux for soldering cast iron. Ellis. (M.) 283
—Forged steel flanges..... 346
—From black sands. Day and Richards. 85
—Graphite in cast iron. Wust. (S.).... 30
—Grondal magnetic separation. Bennie. *134
—Hardening steel. Demozay 397
—Heat content of iron. Oberhoffer..... 366
—High-class steel from pig iron containing chromium, nickel and cobalt. Richards 262, 316
—High-speed tool steel. Taylor. (S.).. 281
—Induced draught with hot air economizers for steel works and blast-furnace boilers. Capron 264
Iron ore situation 486
—Iron paint. Carulla 395
—Iron reduction with gaseous fuel. Arden. (A.) 472
—Iron reduction in rotary kiln. Ellis. (M.) 65
—Lapland iron ore. Stutzer..... 313
— Lash process. (A.), 279, (A.), 322, (M.) 341
378, 440, 455, 479
—Laws of physical chemistry. Juptner.. *438
Magnetic concentration. (See Concentration and Separation.)
—Magnetic roasting. Wiffley. (M.).... *330
Manganese steel. Hadfield 236, 283
—Market..6, 40, 74, 116, 163, 206, 256, 300, 341
399, 438, 488
Melting cast iron. Geilenkirchen. (S.) 98
Metallography and hardened steels. Longmuir 396
—Nitrogen in iron. Braune 51
—Nomenclature 313
—Open-hearth process 164
— Richards..... 44, 79, 129
— Delporte. (M.) 424
— Allen. (M.) 506
— Naske 139
Osmondite. Howe *347
Passivity of iron. Heathcote (S.)... 464
"Physic" for pig iron. Davies. (M.). 328
—Pickling steel. Reed 220
Piping. Howe (S.) 194
Preserving iron and steel work in railway construction. Blount..... 318
Process of manufacture and physical properties. Harbord 263, 316
—Rails. Metal..... 205, 257
composition. Sandberg 317
Corrugation. Beaumont 408
— Breakage 206
— trade. Developments in 253
—Rapid-cutting steels. Le Chatelier. (S.) 64
—Reduction of iron by oil and gas. McDonald. (M.) 423
—Removal of iron pyrites. Blackmore and Howard (M.) 64
Removing scale from iron. Reed (A.) 280
Roasting and agglomerating pyrite cinder. Hall. (M.) *148
Seamless iron receptacles by electrolysis. Edison (A.) 415
Segregation in steel. Stead..... 372
Self hardening steel. Churchward. (M.) 196
Shrinkage cavities in steel ingots. Ohholzer. (S.) 509
—Silicon and carbon in iron alloys. Wüst and Petersen (S.) 61
Special steels 54, 149, 379, 472
Statistics 139
Steel dies. Diez (A.) 325
Steel from high-sulphur phosphoric pig iron by basic Bessemer process. Richards 262, 315
Steel for gun forgings. Churchward (M.) 148
Steel impurities, non-metallic. Law.. 313
—Steel and meteoric iron. Berwerth .. 398
Steel for ships 373
Steel works machinery 376
Structure of wrought iron. Seaver ir *119
—Substitute for charcoal iron. Totten. (M.) 241
Temperature measurements (See Pyrometry.)
Titanium. Slocum 511
Titanium-calcium-aluminium alloy for steel. Becket. (A.) 322
Treatment of ferruginous zinc blende. Johnson. (A.) 470
— Turbine furnace. De Laval..... *124
Tuyers. MacDonald. (M.) 328
—Vanadate of iron analysis. Wilson.... 495
—Vanadium in steel. Smith 494
—Vanadium steel. Puetz and Guillet. (S.) 420
—Voltax paint 336
—Welding compound. Hanlon. (M.) .. 424
— Wiesmann. (M.) 94
— Ferrofix 60
Iron and Steel Institute 206, 381
—London meeting, report...262, 275, 312, 315
—Vienna meeting, report 392, 462
Italy. Electrochemistry in 197

J

JAMESTOWN Exposition 93, 197
Johns-Manville Co., H. D. 287
Jones, Wm. 335

K

KNY SCHERER CO. 107, 154

L

LACLEDE Fire Brick Mfg. Co.....69, 335
Laclede-Christy Clay Products Co..... 335
Lamp. Helion. Parker 230
—New incandescent 95

LEAD:
—Alloys with copper. Friedrich and Leroux. (S.) 281
— with copper and nickel. (M.)..... 61
— with nickel. Partevin (S.)..... 423
— and zinc from sulphides. Baker and Bursell. (A.) 56
—arsenate. Vreeland. (A.) 505
—Chlorine treatment of lead-zinc sulphides 448
—chromate by electrolysis. Chaplin. (A.) 504
—Condensation of fume. Friedrich. (S.) 31
—Electrochemistry of. Cumming..... 8
—Electrolytic refining.....347, 468
From lead-zinc sulphides. Froneck (M.) 196
—from sulphides. Anderson. (A.). *142, 415
—Joining pipes and cables. Smith and Harden. (A.) 472
—Lead-lined hose *331
—oxide. Bailey. (M.) 196
— Townsend. (A.) 470
—pigment. Sperry. (A.) 471
—Removal of zinc sulphide accretions in reverberatory forehearths 40
Roast-reaction process. (S.)..... 376
—Lime roasting. Savelsberg. (M.)..... 507
—Roasting. Lotti. (M.) 169
—Silver-lead smelting. Austin 244
—Treatment of sulphides. Dedolph. (M.) 507
in Upper Mississippi Valley.. 152
Lead white. Townsend. (A.)..... *142
Chaplin. (A.) 504
Leeds & Northrup Co. 231, 335
Lehigh University 107
Library. Free engineering 473
Light. Effect on formation of sulphuric acid. Coehn 458
Lightning arrester. Electrolytic. Jackson. (S.) 375
Lime kilns. Producer gas for. Nagel..... 369
Linde Air Products Co. 476
Liquid air. Industrial *426
Lithopone Candau. (A.) 471
Lubrication. Deflocculated graphite..... *452

M

MAGNESIA. Action of carbon on Watts 224
Magnesite. Austrian 154
Magnesium. Alloy with calcium. (A.) .. 414
— for copper sand castings. (S.)..... 147
— by electrolysis. Seward and Kuegelgen. (A.) 470
Manganese 69
—Aluminothermic process. Goldschmidt and Weil (M.) 370
—alloys. Wologdine. (S.) 101
—carbide. Decomposition. (S.) 31
—silicide. Price (A.) 412
Melting points. Burgess 469
—Harker 48
—Maeulen 76
—Arndt 161
—Clement 321
—of tungsten 467
—of metals. Loebe 467
Mende-ejeff 71
Congress of Chemistry 489
Mercury. Condenser. Brown. (M.) 150
—Retort and furnace. Brown. (M.).... 150

—Cathode for measurement of potential in solutions.
—Jacket 227
Measurement of Specific Inductive Capacity 512
Metals (See also the different metals)
—Cutting with oxyhydrogen flame *388, 381
—Melting 428
—Melting point 72, 97, 341, 435
—Recovering from mines by Electric Conductivity 189
—Thermo-electric Series 387
Metallography 204
—Alloys 204
—Preparing for 30
—Thermo-electric Diagrams 396
—Use of Carborundum in ..... Howe. *347
—Use of Electric Furnace in *119
Micrometer, Screw, and Circle Gauges, Reed 218
Mining Laws 487
Mining Machinery 204
Mining Operations 497
Mining Plants (See) 36, 71
—in Hunan and Dieremus *127
Molybdenite, Kunz 453
Monazite, Potter 413
Motor-generator for electrolysis *34
Multimeter 198, *287

N

NATIONAL Aniline & Chemical Co. 69
National Carbon Co. 69
National Physical Laboratory 231
National Tube Co. 479
Nernst 52
New York Brick & Paving Co. 36, 475
New York Flexible Metallic Hose & Tubing Co. 341
Niagara Electrochemical Co. *34
Niagara Falls 66, 69, 106, 515

NICKEL:
—Mond process, Langer, (M.) 425
—Orford process, Maffett, (M.) 34
—Treatment with chlorine, Diehl and Koehler, (M.) 150
—by electrolysis, Ehrenfeld and Grove, (S.) 470
—Treatment of Nickel Copper-Cobalt Iron Ores, MacIvor, (M.) 329
—From basic nickel precipitates, Dow, Cates, Schaefer, (M.) 329
—From nickel-plated scrap, Richter, (S.) 61
—Nickel copper, cobalt from sulphides or arsenides, Ryan, (A.) *56
—Cobalt arsenides, Baker 448
—Roasting argentiferous cobalt-nickel arsenides, (S.) 147
—Nickel-silver plating, Marshall, (A.), 416
—Roasting of nickel plate, Calhane and Cummage, (S.) 468
—Production of Nickel-chloride, MacIver, (M.) 150
—Oxide, Willson, (A.) 149
—Electrolytic Deposition, Smoch and Hirsch 228
—arsenic alloys 423
—lead alloys 423
—tin alloys 423
Nitrates, (S.) 467
Nitric acid, Reduction 442
Nitrogen, From liquid air *426

NITROGEN, FIXATION OF ATMOSPHERIC:
—in the form of calcium cyanamide 72, 198, 289, 374, 479
—Carbon, (S.) 98
—Eilhard 59, *77
—Eisenhut and Jacobs 464
—Bradley 465
—in the form of nitric acid and nitrates, ... 72, 342, 479
—Ayres and Parks 258
—Birkeland and Eyde 33
—Bradley and Durand 465
—Dunnige *463
—Erwein *77
—Howles *238
—Maxted *491
—Neuburger 197
—Nitrum de LeBlanc, Grau, Russ. 464
—Steinmetz 418
—in form of ammonia or nitrates.
—Nernst 457
—Weidenhuse 361
Nitrogen Compounds 515
Nitrogen, Water power 516

O

OIL, Fish—treatment of, De Hemptinne, (A.) 241
—Hydrogenation, Purification, Neithing, (A.) 289
—Paint 230
—Refining 515
Ozonizer, Howe *347
Ozonizer, Electric, Frazer and Holmes 256
Ozonizer pressure 105
—Results 226
Overspecialization, Danger of, Baekeland 391
Overvoltage, Kaufler, (S.) 467
Oxygen, From liquid air 509
—uses in metallurgy *426
Oxyacetylene blowpipe for welding 456
—for cutting *288
Ozone apparatus 308, 381, 420, 426
—Test of ozonizer, Ewell 206, 280, 319, 419, 506

P

PAINT, Waterproof *264
Pangborn Co., Thomas W. 335
Paper pulp, Bleaching 334
Passive state, (S.) *178
Patents, British electrochemical expiring in 1907 ..... 467, 468
Pearce Co., Frederick 237
Peat, Utilization, (S.) 69
Pebble Mills, Abbe, (M.) 145, 387, 392, 406
Perkin, Sir William 383
Perrin, William R., & Co. 382
Phosphorus, Manufacture 67
—Alloys with copper *55, 378, 407, 412
Pinch effect 282
Pipe, Welded steel 87, *223
Piqua Blower Co. 479
Pittsburgh Plate Glass Co. 36
..... 154

PLATING:
—Anode 195, 416
—Apparatus 104, 143, 145, 416, 471, 505
—Ceramic vessels 239
—Gold, Hutchinson, (A.) 32
—Influence of temperature, Foerster 458
—Lace with metal, Daly, (A.) 104
—Making abrasive body, Case, (A.) 416
—Metallized wallpaper, Livingston, (A.) 33
—Multimeter and Voltmeter *287
—Nickel-silver, Marshall, (A.) 416
—Nickel-zinc 228
—Recovering gold from gold-plate scrap (S.) 468
—Rusting of nickel plate 468
—Separators, Greist, (A.) 417
—Sheets—continuously 379
—upon aluminium 282
—Zinc 222, *231, 471
—Zinc, Sheradizing 153, *187
Platinum substitutes 140
Polarization voltage of silver nitrate solutions 224
Porcelain-lined iron kettles 197, 299
Porous metal, Manufacture, Edison, (A.) 195
Potash from feldspath, (A.) 280
Potassium by electrolysis 56
—hydrate, Transference numbers, (S.) 465
Potential of hydrogen at metals 236
Powell, Wm., Co. 430
—Valve *514
Power & Mining Machinery Co. 154, 195, 430
Power costs, Comparative 291
—Lucks 230
—(See also Gas.)
Power factor, Electrochemical processes as station load equalizers, Meyer 229

PRIMARY BATTERY:
—Blameuser, (A.) 58
—Brown, (A.) 58
—Cochrane 418
—Decker, (A.), 58 (A), 104 (A.), 144 (A.), 195 (A.), 327
—Divine and Shinn, (A.) 418
—Edison (A.) 417
—Downs, (A.) 418
—Gernsback, (A.) 104
—Hite, (A.) 418
—Krause, (A.) 195
—Manville, (A.) 418
—Marks, (A.) 418
—Poersche and Wedekind, (A.) 104, 195
—Schalow, (A.) 195
—Schoenmehl, (A.) 195
—Siemens-Obach 236
—Stout (A.) 327
Producer gas, (See Gas.)
Prophesy in engineering 39
Pumping, Electric 502
Pyrometers 5
—Bristol *289, *177
—Brown & Son 69
—Heraeus-Le Chatelier, Engelhard 335
—Leeds & Northrup Co. 335
—Wilson-Maeulen Co. *197, 335, 476
—Radiation 335
—Sentinel pyrometers 312
—Electric tube furnace for temperature measurements, Tucker *227
—High-temperature scale, Burgess 230
—Thermoelements, White, (S.) 31

Q

QUARTZ, fused, for pyrometer tubes 67

R

RADIOACTIVITY 409, 452, 456
Raquette Foundry & Supply Co. 475
Rectifier Electrolytic, de Faria, (S.) 145
—Hickley, (A.) 419
—Rothenstein, (A.) 419
—Schultz, (S.) 375
—Sebor and Simek, (S.) 466

REFINING:
—bismuth, Mohn *314
—copper, Richards 458
—in Australia 248
—Betts, (A.) 327
—lead 327, 468
—tin, Steiner *309
Refractory 335
—Cupola linings 152
Resistance, To impact 235
—Measurement of electrolytic, Burgess, *224, Franklin and Freudenberger 467
Resistors, (See Furnace, Electric.)
Revue de l'Electrochimie 153
Roessler & Hasslacher Chemical Co. 36, 509
Roozeboom 71
Royal Society Conversazione, Exhibits 317
Rule of thumb versus engineering, Richards 4
Rutherford 108

S

SAFE-BLOWING 381
Sampling 94
Sand-blast for cleaning castings 334
Sand for glass 291
Sapphires, Coloration by radioactivity 511
Sarco Fuel Saving & Engineering Co. 106
Schoop, M. U. 70
Schutte & Koerting Co. 333, 381
Scottish Cyanide Co. 463
Separators, (See Concentration.)
Sewage treatment, (See Sodium chloride electrolysis, Hypochlorite.)
Shaker for laboratories, Camp *270
Sharon Chemical Co., Ltd. 395
Silica, Reduced by aluminium, Weston and Ellis 489
—Vases of cast 479
Silicides, Tone, (A.) *141
Silico-manganese 429
Silicon, Alloys, Tone, (A.) *141
—Analysis, Albro and Mott 445
—Copper-silicon, Philips, (S.) 468
—monoxide, Potter 442
—as reducing agent 237
Silicosplegel 322, 513

SILVER:
—Alloys with copper, Friedrich and Leroux, (S.) 281
—Assay of bullion 94, 147
—coulometer, Duschak and Hulett 451
—Metallurgy of Silver Ores, (S.) 30
—Nickel-silver plating 416
—Production in 1906 515
—Refining at mint 234
—Roasting argentiferous cobalt-nickel arsenides, (S.) 147
—Silver-lead ores 244, 430
—nitrate solutions, Polarization voltage, Wilkinson and Gillette 224
—Valency 466
(Numerous articles given under Gold also refer to Silver. See Gold.)
Smith, Emery & Co. 108
Society of Chemical Engineers 285
Society of Chemical Industry 209, 212, 429
Society of Detroit Chemists 479
Sodium, By electrolysis 56, 238, 470
Sodium nitrate electrolysis 466
Sodium oxide by electrolysis 325

SODIUM CHLORIDE ELECTROLYSIS:
—Caustic and chlorine 107, 204
—Diaphragm cells 463
—Gabriel cell *326
—McDonald cell *13, *261
—Townsend cell *209, 239, 258, *301
—Mercury cathode, Allen, (A.) 378
—Aussig glocken (gravity) process *171
—Chlorates 375
—Hypochlorite, Digby 7, 26, 53, *178
—Hargreaves-Bird 235
—Hermite 7
—Schoop *50
—Meridionizer 502
—Water sterilization 53, 335
—Bleaching cotton, Vogelsang, (A.) 471
—Metallic sodium 56, 238, 470
—Sodium oxide 225
Solutes and solvents, Rhodin 256
Speed recorder, Brown *380
Standardization rules, Institution of Mining and Metallurgy 512
Station load equalized by electrochemical processes, Meyer 229
Steam power 230
Steel, (See Iron and Steel.)
Stevens Institute of Technology 291
Still, Automatic *35, 334
Stokes, F. J., Machine Co. *105, *334
Stoneware cocks *290

STORAGE BATTERY:
—Charging, Ramyer, (A.) 33
—Cleaning, Aylsworth, (A.) 33
—Electrolytes, Vincatey 8
—Floating in steel plant 514

—Treatment of negatives..... 113
Various designs.
— Berst, (A.) 379
— Bijur, (A.).....58, 113, 143, 240
— Bradbury, (A.) 144
— Chronik, (A.) 418
— Clark, (A.) 57
— Cook and Sokal, (A.)..... 505
— Diamant, (A.) 418
— Edison, (A.)..58, 195, 240, 317, 413, 417 465, 506
— Ford, (A.) 240
— Fredet, (A.) 418
— Gardiner, (A.) 418
— Harvey, (A.) 418
— Hood, (A.) 57
— Knobloch, (A.) 418
— Lake, (A.) 143
— Landsing, (A.) 58
— Leitner, (A.) 472
— Leonard, (A.) 144
— Little, (A.) 505
— Lyndon, (A.) 240
— Marx, (A.) 472
— Morrison, (A.) 143
— Roselle, (A.) 195
— Schalow, (A.) 195
— Sokal, (A.) *240
Stuart & Peterson Co.....69, 197, 290
Sulphides, Reduction.....*142, 237, 322
Sulphur Burner, Agitating *479
Sulphur ebloride 69
Sulphuric acid, electrolysis, Mueller and Schellhaas, (S.) 466
—formation, Effect of light, Coehn.... 458
—towers, Ball filling for..... 151
Switchboard instruments, Long-scale..... *246

T

TANK for electrolysis, Miller, (A.)..... 280
Tantalum.....68, 419, 467
Technical Publicity Association..... 429
Temperature, Measurements, (See Pyrometer.) ..... in
Tetrachloride of carbon, Crocker..... *259
Thermit.....196, 248, 283, 285
Thermostatic apparatus, Lowry 276
Thomson, J. J. 36
Tile, Acid-proof 473

TIN:
—Detinning....*103, 284, 321, *326, 345, 346, 375 379, 511
—Electrometallurgy, (S.) 468
—Neutral soldering flux, Lanigan, (M.) 285
—Nickel-tin alloys, Guillet, (S.).... .. 423
—Refining, Steiner *399
Removal of iron, Brandenburg, (M.) 329
Smelting, Brandenburg, (M.) 330
—Tin Products Co. 153
Titanium Manufacturing Co..... 69
Towers, Ball filling for..... 151
Traylor, John A., Machinery Co..... 305
Tube mills.....101, 146, 191, *296, 422, 429
Tungsten.....425, 467, 515
Turbo-blowing engines, (S.)..... 32

U

UNITED Engineering Societies Building. 164
United States Electro Galvanizing Co..... 331
United States Steel Corporation.....68, 153, 154
Universal Portland Cement Co..... 107

V

VACUUM-TUBE light, Moore 184
Valve, Fisener gas-valve 290
—Powell Co. *514
Vanadium.....322, 379, 412, 494, 495
Vanadium Alloys Co. 495
Virginia Electrolytic Co. 146
Voland & Sons 68
Voltage of polarization of silver nitrate solutions, Wilkinson and Gillet e.... 224
Voltax paint 336
Voltmeter.....*66, 153, *246, *287
von Foregger, Richard 509

W

WAGNER Water Still Co..... *35
Waller & Renaud 108
Wallpaper, Metallized, Livingston, (A.) 33
Water gas 19, 41, 510
Water-power, Cost 230, 410
Water purification by electrolysis, Dieterich.....57, 164, 416, 417
—by hypochlorites 335
—by ozone 300
Watt-, volt-, am.-, hp meter combined.... *287
Welding 261
with thermit.....196, 283, 285
—with oxy-acetylene blowpipe..... *288
—with epurite 288
—Compounds for iron.....34, 69, 424
— Welded pipe 479
—Flux for copper 149
Weldite 248
Wellman-Seaver-Morgan Co..... .....68, 69
Welsbach Light Co. 234
Wendell & MacDuffe 154
Western Electric Co.....69, 153, 198
Western Tube Co. 335
Westinghouse Electric & Mfg. Co. 336
Weston Electrical Instrument Co.... . 287
White lead, Sperry, (A.)..... 471
—Townsend, (A.) *142
Wile Power Gas Co. 291
Willson Aluminum Co.....146, 167, 248
Wilson-Maeulen Co.67, 107, 157, 231, 325, 476, 480
Wool washing and cleaning by electrolysis, Burton, (A.) 239
Worcester Pressed Steel Co..... 288
Work done in electrolysis, Richards..... 219
Workman, The American 73

Z

ZINC:
—Alloy with calcium, (A.)..... 279
—with copper, (M.) 242
—with iron 69
—with nickel 278
Belgian and World industry..... 291
Bronze, Ruebel, (M.) 280
Charging retorts..... 212, *330
—Chlorine treatment of lead-zinc sulphides, Baker 448
Cold galvanizing *331
—Decomposition of blende..... 148
deposition 222, 471
—Distillation furnace, Desgraz and Schmidt, (M.) 97
—Dust in cement..... 248
—from complex sulphides.....56, *57, 64, *142 150, 196, 379
electrometallurgy, Johnson 83
—electric smelting, Blount.....265, 273
— Gin *446
Johnson 83, 470
Taylor *107, 228
Snyder *323, 489
Furnace, Lanyon, (M.) 64
— de Laval, (M.) *241
—in Upper Mississippi Valley..... 152
—New works 287
Retorts, Queneau, (M.) 33
Roasting, Angell, (M.) 33
—Magnetic roasting, Wilfley, (M.).... *330
Sherardizing, Sang *187
—Surface properties 231
—Zinc oxide reduction, Johnson..... 498

AUTHORS' INDEX

ACHESON, Edward G. Deflocculated graphite *452
Albro, A. Bliss. Analysis of silicon compounds 445
Arndt, Karl. Fused salts..... 457
—Melting points of Elements..... 164

BAEKELAND, Leu H. The danger of overspecialization 391
—The new electrolytic alkali works at Niagara Falls *409
——The Townsend cell for sodium chloride electrolysis 301
Baker, Charles E. Chlorine in metallurgy 448
Barnhart, Edwin. Rapid and accurate gas analysis *350
Beaumont, Worley. The origin and production of corrugation of tramway rails 409
Benjamin, Marcus. Charles Frederick Chandler *49
Bennie, P. McN. Electric smelting for the foundry 75
——Magnetic separation of iron ores by the Grondal Process *134
Bennie, P. McN., and F. A. J. Fitzgerald. The Lash steel process and the electric furnace 455
Bent, Leavitt N., Walker, William H. and Cederholm, Anna M. Corrosion of iron 363
Berkeley, Earl of. Osmotic pressure.... 125
Bernoulli, A. L. Atomic Weights 457
Berwerth, Fred. Steel and meteoric iron. 398
Bigge, D. Selby. Electrically driven reversing rolling mills 262
Biggs, Charles V. The Hermite electrolytic process at Poolar 7
Bone, W. A., and Wheeler, R. V. An investigation on the use of steam in gas producer practice..... 263
Brakenbury, H. I. Modern machinery and its future developments..... 410
Brauner, B. Atomic weights..... 457
Brearly, H., and Moorwood, F. Colin. Sentinel pyrometers and their application to the annealing, hardening and general heat treatment of tool steel 312
Brenil, Pierre. Copper steels 312
Brooks, J. F. A machine for weighing the forces on a cutting tool..... 410
Browne, David H. The use of graphic formulæ in metallurgical calculations *174
Burgess, Chas. F. Rapid measurement of electrolytic resistance *224
Burgess, Geo. K. Measurement of high temperatures 220

CAMP, J. M. A new shaking device for the chemical laboratory *270
Carhart, Henry S., and F. J. Mellencamp. Concentration cells 451
Carulla, F. J. R. A new iron paint and a new application of calcium chloride from the pickling process 395
Cauchois, R. W., Tucker, Samuel A., and A. Doty. Granular carbon resistors 450
Cederholm, Anna M., Walker, William H., and Bent, Leavitt N. Corrosion of iron 363
Chandler, Charles F. Presidency of American Electrochemical Society 490
Claudet, Arthur C. The assay of gold bars as conducted in the author's assay office 74
Cloud, T. C. The McMurtry Rogers process for desulphurizing copper ores 277
The Walleroo Smelting Works, in South Australia 57
Cohn, L. M. Electric annealing and hardening furnace 428
Crocker, J. R. Manufacture and uses of carbon tetrachloride..... *259
——McDonald electrolytic bleach and caustic soda plant *43
The Townsend cell for sodium chloride electrolysis 268
Cumming, A. C. C. Contribution to the study of strong electrolytes..... 8
——The electrochemistry of lead..... 8
Cushman, A. S. The corrosion of iron an electrolytic phenomenon.....257, 365

DAY, David T. Iron and steel from black sands 85
de Rissett, E. W. The use of high-tensile steel in the construction of the "Mauretania" 373
Demozay, L. Hardening of steel 297
Denny, G. A. Problems of the Witwatersrand gold fields 371
Digby, W. Pollard. Hypochlorites and the safeguarding of water supplies 58
——The depreciation of electrolytically produced solutions of sodium hypochlorite 7
——The problems of bleaching with paper-pulp electrolytic hypochlorite solutions *178
Doremus, Charles A. Pierre Eugene Marcellin Berthelot *182
—Professor Henri Moissan *127
Doty, A., Samuel A. Tucker and R. W. Cauchois. Granular carbon resistors 450
Duschak, L. H., and G. A. Hulett. Silver coulometer 451

EICHHOFF, Fr. The Heroult process as operated at Remscheid, Germany 25
Ellis, H. R. Action of aluminum on silica and boric anhydride..... 489
Erlwein, Georg. Fixation of atmospheric nitrogen *77
Evans, J. W. The electric furnace in iron and steel metallurgy 25
Ewell, Arthur W. Test of an ozonizer *264
Eyermann, Peter. Compound steel. A modern steel plant proposition.... *122

F [illegible] 126
[illegible] 440
[illegible] 451
[illegible] 455
[illegible] 229
[illegible] 478
[illegible] 20
[illegible] 94
[illegible] 392
[illegible] 405
[illegible] *449

G [illegible] 221
[illegible] 22
[illegible] *443
[illegible] 443
[illegible] 445
[illegible] *367

H ALL, Charles M. Presidency of American Electrochemical Society 440
Hall, W. J. Surface properties of aluminium and zinc 201
Harrod, F. W. Relation between the process of manufacture and some of the physical properties of steel. 263
Harden, John. The electric induction furnace 25
Hatfield, W. H. Cast iron as cast and heat treated 313
Heberson, J. The distribution of sulphur in metal ingot moulds 312
Hering, Carl. A practical imitation of resistance furnaces—the pinch phenomenon *223
——American Electrochemical Society.. *217
——Presidency of American Electrochemical Society 440
Herty, A., and Schoch, E. P. The electrolytic deposition of nickel-zinc alloys 228
Hodgkinson, E. Ferro-alloys in the foundry 312
Howe, Henry M. A new iron-carbon phase, Osmelite *347
Howles, F. Electrochemical combustion of atmospheric nitrogen *358
Hulett, G. A., and L. H. Duschak. Silver voltameter 451
Hurdt, A. Bleaching liquors *50
Hussak, R. S. Professor Henri Moissan. *127
——The electric furnace in iron and steel metallurgy 24
——The electric furnace in the pottery industry *90
——The Girod ferro-alloy works and the new Girod steel furnace *9

J OHNSON, W. M. A. Electrometallurgy of zinc 83
——Physical factors in the metallurgical reduction of zinc oxide 498
Johnston, Hartley, and Hanks. Application of the laws of physical chemistry to the metallurgy of iron 438, *500
——Water gas *19

K AHLENBERG, L. The bearing of certain electrochemical experiments upon the conceptions of the nature of [illegible] 126
Kennedy, Walter. Blast furnace top-cone construction *120
Kent, W. The American iron industry during the last twenty-five years 396
Kershaw, J. A. Statistical review 411
Kilgour, G. F. Diamonds and meteoric stones; artificial and meteoric 473

L IEB Mark R. The Butters slime flotation plant of the Consolidated Mines Company 88
Lanchester, [illegible] An electrically-driven [illegible] engine-ore testing machine 416
Law, E. [illegible] The non-metallic impurities of steel 313
Lightfoot, Cecil. Oxygen in the arts 456
Lincoln, A. T. Electrolytic corrosion of brasses 228
Lorimur, Percy. Hardened steels and metallography 396
Lewis, Henry. Special methods of shaft sinking 371
Lowry, T. M. Osmotic pressure from the standpoint of the kinetic theory 125
Lucke, Charles E. Power costs 239

M ACGREGOR, Frank S. and Albert E. Greene. The electrothermic reduction of iron ores *367
——Electrometallurgy of iron 445
Maculen, Frederick. Melting points 76
Mann, E. H. Arrangement and design of colliery surface works 372
Marckwald, W. Chemical behavior of radioactive substances 456
Mellencamp, F. J., and Henry S. Carhart. Concentration cells 451
Meyer, G. Production of helium from radioactive substances 456
Mohn, Arnold. Electrolytic refining of bismuth *314
Meldenke, Richard. Electric smelting for the foundry 42
——The electric furnace in the foundry. 207
Morse, H. N. Osmotic pressure 126
Moscicki, I. Nitric acid from air *491
Mott, William Roy. Determination of silicon 445
——Some considerations on the efficiency of electrolytic cells 218

N AGEL, Oskar. Producer—gas-fired muffle furnaces *338
——The Gayley dry-blast process 302
——The use of producer gas in the chemical industries *369
——Water gas *19, 42
Naske, Theodor. The open-hearth steel process 139
Nernst, W. Synthesis of ammonia 457
Northrup, E. F. The "pinch effect" 87

O FFERHAUS, C. Detinning with chlorine 346

P ARKER, H. J. Helion lamp 230
Patten, Harrison E. Electrolytic reduction of nitric acid 449
——Energy changes accompanying adsorption 225
Perkins, F. Mollwo. Reduction of oxides and sulphides by metallic calcium, 276, 490
Philipp, Herbert. Gas analysis 449
Potter, Henry Noel. Electric furnace for making monox *444
——Monox 443
——Oxidation heat of silicon 229
——Silicon monoxide 442
Pratt, L. Reduction of oxides with calcium hydride 490

R AMSAY, William. On the variability in the products resulting from changes in radium emanation 371
Reed, C. J. Changes of concentration and migration velocities 218
—— Pickling of steel 220
Richards, A. Windsor. Manufacture of steel from high-silicon phosphoric pig iron by the basic Bessemer process 262
——Production of high-class steel from pig iron containing chromium, nickel and cobalt 262
Richards, J. W. Metallurgical calculations... 11, 44, 79, 129, 165, 212, 266, 301, 352, 398, 458, 496.
——"Bringing forward" of copper matte 352
——Electric smelting of copper ores 496
——Electrolytic refining of impure copper 458
——Electrometallurgy of iron 446
——Pyritic smelting 301
——Roasting and smelting copper ores. 212
——Smelting of copper ores 266
——The electrometallurgy of copper 398
——The electrometallurgy of iron and steel 165
——The open-hearth furnace 44
——The temperature increment in the Bessemer converter 11
——Thermal efficiency of open-hearth furnaces 79, 129
——Nitrogen in iron 51
——Rule of thumb vs. engineering 4
——The heat content of iron *366
——Water gas 41
——Work done in electrolysis 219
Richards, R. H. Iron and steel from black sands 85
Richards, Theodore W. Compressibility of elements 457
Roechling, Hermann. Electric steel..*92, *172

S ANG, Alfred. Theory and practice of sherardizing *187
Sauveur, Albert. The structure of wrought iron *119
Schlundt, Herman. Radioactivity 452
Schoch, E. P., and Hirsch, A. The electrolytic deposition of nickel-zinc alloys 228
Scholl, George P. Modern gold mining. 14
Schoop, M. W. A burner for cutting metals *308
Scott, G. Shaw. Case hardening 396
Seaton, A. E. The use of high tensile steel in compound structure, such as ships, bridges, etc 373
Shipley, G. B. A modern electrically operated copper converter *244
——Modern copper converters, hydraulically operated *474
Slocum, Charles V. Titanium in steel metallurgy 511
Smith, Edgar F. Recent developments in electroanalysis 219
Smith, J. Kent. Vanadium 494
Snowdon, Ralph C. Electrodeposition of zinc 222
Snyder, E. T. Electric zinc smelting 489
Steele, B. D. Electrolysis at low temperatures 489
Steiner, Otto. Electrolytic refining of tin *309
——The Aussig Glocken process for alkali chloride electrolysis *171
Steinmetz, C. P. Electric conduction 221
Sticht, Robert. Pyritic smelting 302
Stose, George W. Production of phosphorus in the electric furnace 407
Stromeyer, C. E. The ageing of mild steel 264, 395
Strutt, R. J. Helium and radioactivity in common ores and minerals 409
Stutzer, Otto. The Genesis of the Lapland iron ore deposits 313
Swindon, Thomas. Carbon-tungsten steels 312

T AYLOR, Edward R. Electric zinc furnace 228
Thatcher, C. J. The Moore vacuum-tube light and the luminosity of gases.. 185
Thomson, J. J. The modern theory of electrical conductivity of metals.. 189
Thwaite, B. H. Economic distribution of electric power from blast furnaces. 395
Tucker, Samuel A. Electric tube furnace for temperature measurements *227
——Granular carbon resistance furnace. *227
——Presidency of American American Electrochemical Society 490
Tucker, Samuel A., A. Doty and R. W. Cauchois. Granular carbon resistors 450

V ICAREY, R. W. Storage batteries and their electrolytes 8
Voge, A. L. Card index 41
von Ehrenwerth, Josef. Determination of blast-furnace gas 394
von Lerch, F. Nature of radioactive radiation 456

W ALKER, William H., Anna M. Cederholm and Leavitt N. Bent. Corrosion of iron 363
Walker, W. H. Influence of stress on the corrosion of iron 224
Walker, Wm. H., and Colby Dill. The effect of stress upon corrosion of iron *270
Watts, Oliver P. Boiling points of metals 450
——The action of carbon on magnesia at high temperatures 224
Weston, F. E. Action of aluminium on silica and boric anhydride 489
Wheeler, R. V., and W. A. Bone. An investigation on the use of steam in gas-producer practice 263
Whitehouse, Norman. The fixation of nitrogen 261
Wilkinson, J. A., and H. W. Gillette. Polarization voltages of silver nitrate solutions 224
Wilson, Arden M. Technical analysis of vanadate of iron 495

Y ARROW, A. F. High-tensile steel for torpedo-boat construction 373

Electrochemical and Metallurgical Industry

VOL. V. NEW YORK, JANUARY, 1907. No. 1.

Electrochemical and Metallurgical Industry

With which is Incorporated Iron and Steel Magazine

Published on the first of each month by the
ELECTROCHEMICAL PUBLISHING COMPANY,
[*Incorporated.*]
114-118 LIBERTY STREET, NEW YORK.

J. W. RICHARDS, PH. D.....*President*
E. F. ROEBER, PH. D.....*Editor*

Subscription Price: $2 per year, postpaid to any part of the world. Single copies 25 cents.

Copyrighted, 1907, by the Electrochemical Publishing Co.

Entered as Second-Class Matter, June, 1903, at the Post-Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, JANUARY, 1907.

CONTENTS.

EDITORIAL 1
Metallurgy in 1906 1
Electrochemistry in 1906 2
Excess of Prosperity 2
President Roosevelt and Technical Training 3
Rule of Thumb versus Engineering. By J. W. Richards 4
The Iron and Steel Market 6
Faraday Society 7
CORRESPONDENCE:
Electric Steel-Noble Electric Steel Company 8
The Girod Ferro-Alloy Works and the New Girod Steel Furnace. By R. S. Hutton 9
Metallurgical Calculations. By J. W. Richards 11
Modern Gold Milling. By George P. Scholl 15
Water Gas. By Oskar Nagel 19
The Electric Furnace in Iron and Steel Metallurgy 24
NOTES ON ELECTROCHEMISTRY AND METALLURGY IN GREAT BRITAIN 26
SYNOPSIS OF PERIODICAL LITERATURE 28
ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS 32
RECENT METALLURGICAL PATENTS 33
BOOK REVIEWS:
A Laboratory Guide to the Study of Qualitative Analysis 34
Electrolytic Motor Generator 34
Automatic Water Still 34
NOTES 35
PERSONAL 36
DIGEST OF UNITED STATES PATENTS (Carborundum) 36

Metallurgy in 1906

The past year, like 1905, was one of general industrial prosperity. In metallurgy we have witnessed both increased output and high prices. After the production of pig iron had reached the enormous figure of 22,992,380 tons in 1905, it appears to have passed well beyond the 25,000,000 mark in 1906. The production of gold, lead and zinc was in each case some 10 per cent larger in 1906 than in the preceding year, while the increase in copper production was 5 per cent. In the case of copper the demand has increased even more than the output, and phenomenal high prices were the natural result. Nor does it seem possible that the situation can change materially in the near future. In the electrical industries as one of the chief consumers of copper, aluminium could, of course, be used as a substitute for copper for some purposes in large quantities. But the demand for aluminium has also been greater than the supply, and the sole producer is said to be many months behind in his orders. The price of aluminium has, therefore, naturally been high; the parallelism between the price fluctuations of copper and aluminium is, of course, in no sense incidental. While it is estimated that the output of aluminium was 30 per cent larger in 1906 than in 1905, a very much larger increase is expected for 1907, since the Pittsburg Reduction Co. is making the very strongest efforts to fortify its already very strong position during the remaining two years for which it is protected in its monopoly by the Bradley patent. This situation in the aluminium industry is a most amusing example of the benefits which may sometimes be derived from a defeat in a long contested law suit.

* * *

The increased production of metals has, of course, gone hand in hand with the specific American tendency to work on a large scale and to push the output to the utmost limit. This tendency is well illustrated by the absolute fearlessness of American metallurgists to design furnaces of dimensions undreamed of not so very long ago—just as our financiers think in millions where their more conservative European brethren are satisfied with figuring in thousands. But this boldness in design and this pushing the output of a plant to the last limit with the aid of automatic machinery will not be found alone sufficient to yield the necessary increase of production. Increased production will necessarily mean in future the treatment of more complex ores, of lean ores, of ores which were formerly considered too difficult to work. This means that metallurgical methods will have to be improved and new methods will have to be found. Above all—and we take pleasure to call attention to the admirable discussion of this phase of the subject by Dr. J. W. Richards printed elsewhere in this issue—it means that the engineer must supplant the rule-of-thumb man. This is the keynote of the whole situation.

Electrochemistry in 1906

Such part of our first volume gives as complete and concise a record of endeavor and accomplishment in electrochemical and electrometallurgical engineering during the past year as could be made, we will touch in this note only on a few salient points. Niagara Falls is still the center of electrochemical industries in this country, and the "old" big furnace industries are flourishing—carborundum, graphite, calcium carbide, artificial emery. The most important new progress which will probably mark the beginning of a new epoch in the graphite industry is Mr. Acheson's success of making artificial soft graphite. But the natural growth of all the established Niagara industries is seriously threatened by the legislation tending toward restriction of further developments of power from the Falls. It is most unfortunate that the whole question is not properly understood by the general public. Even such a distinguished and well meaning chemical scientist as Dr. Clarke, in his able address on this matter, just delivered at the New York meeting of the American Association for the Advancement of Science, always spoke of the case as one of the American public versus the Niagara power companies. As a matter of fact, it is a case of the aesthetic sentiment (real and manufactured) of the American public versus the accomplishments of the Niagara electrochemical industries, with an immense, but by no means, fully understood economic value to the whole American public. At present we have at least the satisfaction that the decision on the most important points rests with a man of the type of Mr. Taft.

* * *

Of new industrial developments with the electric furnace, its application in the iron and steel industry has probably attracted the greatest attention. The manufacture of ferro-alloys is an established electrometallurgical industry, but new is the growing industrial activity in this field in our country. The Willson Aluminum Co., the pioneer ferro-alloy manufacturer and the largest ferro-chrome producer in the world, has occasionally produced ferro-silicon commercially during the past year. While this is no particular metallurgical achievement, it is the first time that ferro-silicon (which has been imported in large quantities from Europe for years past) has been made on an industrial scale in this country. And others are now entering the field in not a half-hearted way. Of very much greater metallurgical interest is, however, the progress of the production of high-class tool steel in electric furnaces, both of the Heroult and of the Colby-Kjellin types. This progress is somewhat slow, but steady, and the success of the pioneer electric steel plants will act as a catalytic agent, increasing the speed of reaction between the conservative steel man and the electrochemical inventor. Of great interest are the results of the Heroult-Haanel experiments on reducing pig iron in the electric furnace, made at Sault Ste. Marie, and the results which the Noble Electric Steel Co. will obtain with the Héroult furnace in California should be carefully watched.

* * *

A second great new achievement in electric furnace industries has to do with the fixation of atmospheric nitrogen. During the past year we recorded the success of two processes. The first is that of Frank for making calcium cyanamide in an electric furnace from calcium carbide and atmospheric nitrogen, the first plant being in Italy. The second process, of Birkeland and Eyde, is the direct combination of the nitrogen and oxygen in atmospheric air by means of electric discharges, the successful plant being located in Norway. Without going into any details, since they have been given in full in our columns, we wish to emphasize that the Birkeland-Eyde process is an electric furnace process pure and simple, the oxidation of the nitrogen being nothing but a thermal effect. The rationale of this reaction is essentially different from the production of ozone by silent discharges through air. Laboratory work with the electric furnace has resulted in immense progress with electric-lamp filaments. First came the osmium, tantalum and graphitized carbon lamps, and they were justly considered as revolutionary achievements. But more revolutionary results were obtained last year, notably with the tungsten lamp. And now has arrived the "helion" lamp, concerning which the information is meagre though remarkable claims are made for it. The lamp is very interesting to the electrochemical engineer. The filament is described as a composite one, with a carbon core and a deposit of silicon. But a compound will result here at the temperature of a glowing filament. Have we here to do with a siloxicon or carborundum filament?

* * *

The electrolytic industries have been no less successful. Among electrolytic fusion processes the production of aluminium naturally takes the first rank; we have spoken about it above in connection with the copper situation. The production of sodium by the Castner process is also steadily increasing. The new process of Mr. Ashcroft, whose success would result in a noteworthy reduction in the price of sodium, is now being tried in Norway. By a remarkable coincidence—it never rains but it pours—we could record in our issue of last May three different propositions for electrolytic lead smelting by Messrs. Ashcroft and Swinburne, Mr. Betts and Mr. Townsend. With respect to industries employing electrolysis of aqueous solutions, the situation has remained unchanged in the production of caustic soda and chlorine from common salt. In electroplating a gradual progress could be noticed in getting away from the rule of thumb. But of greatest industrial importance are in this class, of course, the electrolytic refining processes. Both gold and silver are now electrolytically refined in the Philadelphia and Denver mints, and the San Francisco mint is being equipped electrolytically. The lead refining process of Mr. Betts is operated commercially in three plants, one in this country, one in Canada and one in England. And though last in this summary, yet easily first in commercial importance, we have to record the continuous and splendid growth (a doubling in capacity within five years) of our large copper refineries, on which the whole industrial world on both sides of the Atlantic depends for the supply of refined copper.

Excess of Prosperity.

The general widespread prosperity throughout the country is certainly having most pleasant effects. Labor is well employed and fairly contented, except in large centers, where the ostentation of the newly rich spreads a trail of envy. Technical graduates are thrust into engineering positions and rapidly acquire the practical experience by the "sink or swim" method. Capital is remarkably productive. But the other side of the

shield is not so brilliant. Increase in wages is increasing cost of production. Increase in the rate of interest is hampering industrial undertaking. In short, we have a little too much prosperity. One of the most serious phases of the repleted body politic is the shortage of cars and locomotives throughout the country, but especially in the great West.

* * *

Although the railroads of the country have placed enormous orders for rolling stock in the past two years, and as a result of these increased facilities the gross earnings are from 7 per cent to 10 per cent greater each year, nevertheless the enormous expansion in business in the past two years has made these magnificent additions to equipment look pitiful when viewed in the light of present demand. In fact, the temporary respite in business in 1903, due in part to the sentimental belief in the recurrence each decade of industrial depression was decidedly a good thing for the country. It allowed us a breathing spell in the march of progress. How serious is the car shortage on the business of the country can be seen by fact that it is quite likely that many of the big copper smelting companies of Arizona and Cananea may be forced to shut down, due to lack of coal and coke. The railroads have the right to "commandeer" any coal they need to carry on their own operations. The copper market will feel this most disastrously, for it is in a more or less supersensitive position. The floating supplies of copper are at a very low point The demand is unprecedented. If one important source of production is partly shut off, the price of the metal, already too high, will rise to a figure so high as to throttle the electrical business to some extent, and seriously interfere with the brass business.

* * *

The intimate connection between all forms of industry is thus so strong that the car shortage throughout the country is no less serious to the mining and smelting business than to all forms of industry. While it is acting as a brake on our too rapid expansion of industrialism, to those who feel the yoke it is a condition, not a theory. But in the gastronomic way, it is just as bad for a nation as for an individual to have "too much of a good thing."

President Roosevelt and Technical Training

If it be true, as the philosophers say, that true happiness consists in activity, President Roosevelt must be indeed a happy man. With "mu spelling," with killing grizzlies and giving expert advice to fathers, as advocation, and making peace between two mighty warring nations and acting as general manager of 80,000,000 of opinionated Americans, our President certainly functionizes all his function, and should have reached the "ultima thule" of human happiness. His latest piece of literary endeavor—the recent message to Congress—deals with a most important part of our commercial world, the training of artisans and mechanics, in a thorough and expeditious manner. President Roosevelt gives due tribute to our great technical schools and to the technical research of our great universities But he lays especial stress upon the training of apprentices and workmen by some co-ordinated scheme of manual training schools. He, however, points to the great need of such a development and the many and manifold benefits to be expected, rather than to the exact means of accomplishing the desired results.

* * *

In any trade there is a great necessity for skilled workers. A good mason or machinist is paid wages that make the weekly stipend of the average clerk look like the proverbial thirty pieces of our minimum coinage. And the lot of the highly paid workman from a material standpoint is far ahead of the lot of a college professor. The vast mass of our folk must of necessity be privates in the industrial army. To enable them to learn the methods and acquire the manual dexterity of their work, a complete system of manual education is necessary. This is done more and more by isolated State and city organizations. How the national government is going to further this without increasing the "centralization" of authority, already grown to an extent that would have appalled Alexander Hamilton, is hard indeed to see. Possibly some such system as that used by the Department of Agriculture in its co-operation with the several State agricultural colleges and stations will be the solution.

* * *

The American possesses in great degree the ability to make a living. But he possesses in a slight degree only the ability of using his leisure hours with pleasure. In short, we have not developed the art of living but have developed the business of making a living. To make a young man an artisan is all right. But public opinion should do better. It should show him how to relax and to play. There has been a vast improvement in this. The diversification of industry and the development of machinery has reduced the minimum working day to eight hours. But the other hours are often foolishly spent. If each working family possessed a home with a small acreage devoted to extensive farming and with a poultry yard and a few live stock, the increase in the productivity of the United States would be enormous. This is one way to increase the efficiency of happiness throughout our land. A person's happiness is like the amperes of Ohm's law, his means of satisfying his desires divided by his wants. The current flow of pleasure should be increased by increasing in a rational manner the natural means rather than by decreasing the wants. With all our national wealth and greatness there is some foolishness about the lives of rich and poor save in isolated rare individuals. How to cultivate repose and to relax and divert the streams of energy in other lines—the proper balance between one's powers and his task, the proper distribution between one's physical, intellectual and spiritual faculties, is the greatest question of anthropology. Old King Arthur, who in his wise, practical views of life, seems to resemble our Benjamin Franklin, gave the maxim, "eight hours for work, eight hours for rest, and eight hours for play." Proper industrial training, such as Germany is following up in her slow and scientific manner, but affected by us in our effective American way, will bring about this consummation by increasing the efficiency of the workman. As usual, President Roosevelt has touched a most pertinent question of the times in a most vigorous fashion He will arouse public opinion on this subject, fecundate an idea in many minds, and thus do more towards softening the discordant strain in the life of a nation that ought to be supremely happy.

Rule of Thumb *vs.* Engineering.

The famous Book sentence says: "He ordereth all things by weight and measure." Granting this to be true, we have the highest possible warrant for the principle known as "engineering," the antithesis of "rule of thumb."

The "engineer" is one who strives to perfect his work, the artisan works to get through with it, the first labors for the highest love of his work, the latter "quits when the whistle blows," the first puts "grey matter" into his labor, the latter only muscle and experience.

Ever since man emerged from pre-historic savagery, the one who weighed chances, measured his resources and ordered his actions by intelligent foresight, has earned the place and deserved the title of "the fittest." Engaged as we all are in receiving impressions, recording observations, gaining experience, that man alone is wise who profits by this information to lay down rules for the guidance of his future conduct, for the ordering of his future actions.

The English definition of an inch is that it is "the 12th part of a foot, and equal to three barleycorns." The foot was, of course, originally the average length of the pedal extremities of a race of people and it was not only natural, but inevitable that, for example, the French foot should differ in length from the German foot, etc., etc. Not wishing to pursue this branch of our inquiry to too great and perhaps tiresome lengths, we may as well recite at once a striking and suggestive fact, whose connection with our argument may not be at once apparent; viz., the French word for an inch is "le pouce," which is also the French word for "the thumb." The connection implied is, of course, that an inch, in France, at least, and probably in England also, was originally the length of the second joint of the thumb, which varies less in different people than would at first thought be imagined.

In the absence, therefore, of a proper foot rule marked into inches and fractions, it was customary at one time to measure lengths of small dimensions with the thumb joint and so get an approximation of the number of "thumbs" in a given length. It would be ill-advised, if not conceited, for us to poke fun at or wax sarcastic about the absurdity of such practice, for the "rule of thumb" was a valuable practice when compared with what it displaced—no rule at all; and just as imperfect laws are better than total lawlessness, so the "thumb rule" marked a decided advance towards the arts and sciences.

Somewhere later in time than the period we have been considering, measures of length accurately compared with an arbitrary standard began to multiply and to displace the "rule of thumb." Artisans could then begin to work with exactness, the carpenter could plan and scheme ahead accurately by measure, the smith could forge articles accurately to any required stated size, the gentleman could order from his tailor trousers so many inches long, without allowing for the different lengths of thumb of his sartorial "churls." This period having arrived, and this stage of advancement in the arts and sciences having been reached, we are now prepared to let loose the vials of our criticism, or, perhaps, indignation, and with perfect justification, upon the unlucky wight, who, either from inborn "cussedness" or acquired laziness *continues* to "get by nearly with the rule of thumb." Here is the unpardonable sin: the accurately divided rule has come, and the unregenerated sinner sticks to his "thumbs" and "barleycorns."

Having dragged the reader through this somewhat misty prologue, it is becoming that we state exactly what we mean to talk or preach further about. It is just this: The difference between "rule of thumb" and accurate calculation, the wide gulf separating the bitter-muss cut-and-try methods of the ancients and the scientifically-informed practice of the modern technologist. Not that we are going to hold up the former to ridicule or the latter to extravagant adulation, but we wish to discuss some of the features of modern technology which illustrate the great change which has taken place and the still greater changes which are possible.

To take an illustration from civil engineering: Spanning the Firth of Forth, a few miles above Edinburgh, stands the greatest structure of the present time. With clear spans of 1,700 feet, capable of carrying the heaviest trains, the strains and stresses in each of its thousands of members all accurately calculated beforehand, here is a monument to engineering skill absolutely unthinkable as a product of "rule of thumb."

To take a mechanical illustration: Down in the hold of a monster steamship, compressed within the smallest possible working space, are engines developing, night and day, 40,000 hp. Every nut, bolt and screw has its assigned place, every accurately calculated and measured part its function, every unequal strain is balanced, economical operation provided by a complex system of quadruple expansion, every one of the thousands of parts all working in complete harmony and under exact control. The triumph of mind over matter, you say; yes, but better as an illustration of the infinite superiority of "engineering" over "rule of thumb."

Look once more at the electrical engineer and his achievements. A huge dynamo spins like a top on a shaft 100 feet deep, and develops in the smallest compass imaginable 10,000 hp. The diameters of the armature wires are accurate to the thousandth of an inch, the hundreds of turns of wire are neither one too few nor one too many, the very phases of the pulsations of the electric waves are mapped and studied out so as to bring out the maximum efficiency. Soft iron from Norway, mica from Canada, rubber from Paraguay, copper from Arizona, shellac from China, steel from Pennsylvania, are combined with the most consummate skill and accurate calculation into a huge giant, which works day and night with almost the regularity of a planet. "Rule of thumb" could never have conceived of such a product; only "engineering skill" has made it possible.

One Art and one Science still bear much of the stigma of "rule of thumb:" the Science of Chemistry and the Art of Metallurgy.

Chemistry remained Alchemy until the invigorating breath of modern methods commenced to blow away the mists of mystery which enveloped it. The evolution has been long and laborious. Conservatism in the managers combined with stubborn old-fogyism in the workman, have conspired against enlightening methods to keep the industry in the rule-of-thumb rut. Germany was the first country to break away into scientific and engineering chemistry, and the lead thus gained has been maintained to this day. The Britisher, workman or manager, is the most conservative of human beings, and his backwardness in following Germany's methods is the chief cause of the industrial difficulties under which the British chemical industry now labors.

Metallurgy is still rule of thumb in many countries, such as Central Africa (production of iron), China (production of lead and mercury), Straights Settlements (reduction of tin), where aboriginal methods still largely survive. But, the aboriginal spirit is preserved in many other so-called civilized countries; it persists among the Cornish and Saxon tin workmen, the Derbyshire and Carinthian lead smelters, the Welsh and Mansfeld copper refiners, the Alaskan and Siberian gold winners, the Missouri and the Silesian zinc distillers, the Almaden and Idrian mercury mines, the Eastern Pennsylvania as well as the Lithuanian blast furnaces.

Among all of these, and others too numerous to mention, are to be found that reverence of tradition, that willingness to keep plodding in the rut, that indisposition to apply the discoveries of modern science, that ignorance of what modern science has disclosed, which keep them groping in the semi-darkness of medievalism, while their more intelligent neighbors are running away from them like an express train distancing a stage coach.

To be more specific, and therefore more to the point, let us catalogue the principal items of this indictment, the details of modern scientific discovery whose neglect is the reason for the preceding Philippic. The broad principles involved are simply—neglect to order "all things by weight and measure;" in other words, neglect of the only means by which *intelligent control* can be exercised over chemical and metallurgical processes, or, in still other words, preference of *rule-of-thumb* to *engineering skill*. These principles can be sub-divided, for further consideration, into the observation and utilization of

(1) Weights.
(2) Compositions.
(3) Volumes.
(4) Pressures.
(5) Thermometry.
(6) Calorimetry.

(1) The first and probably most important method of control, is that of *weight*. The use of the scales, to determine how much material is being used and how much produced, and to regulate the items of charging and discharging a furnace or other apparatus, is so nearly universal that it is with difficulty that we can imagine the chemist or metallurgist doing any work without them. Yet there was undoubtedly a time when both chemical and metallurgical operations were conducted without a knowledge of the weights involved, when it was not known that more pounds of ore must be used than pounds of metal are obtained, and when the most delightful degree of irresponsibility must have been felt by the workman as to the output of his process.

We can feebly imagine the tremendous "kick" made by the first Tubal Cain who was furnished with a pair of scales and told to record the weights of all he used and all he produced. How he would execrate the useless labor involved, condemn the "powers that be" to the Styx for increasing his labor so unnecessarily, and even possibly damage the obnoxious weighing machine surreptitiously if he got the chance.

Yet, such behavior sounds too familiar to be altogether confined to ancient history. Is it not true, that even in our day, the scales are not used as much or as carefully as they should be? To put the indictment in a mild form, are not weights taken too little in detail? For instance, the coal used by a furnace, running continuously, is put into a bin and the amount used per week is accurately known; but, if the weights taken out of the bin were determined for each shift of workmen, it might be determined whether the night shift was as economical of fuel as the day shift or not.

In metal-melting establishments, fluxes are often used much more lavishly and extravagantly than they should be; a careful account of the weights used by each melter for each melt would often illuminate matters. All sorts of extravagancies and negligencies may pass for years unchecked if not controlled by careful weighing, carried out in great detail and for each individual unit. The cost of this slightly greater attention to detail will almost invariably be several times repaid by the increased information acquired and more intelligent control thereby made possible.

(2) The question of compositions is the purlieu of the analytical chemist. How slowly the value of this information is being recognized! Next in importance to the amounts of material being used or produced is their quality, and here rule of thumb has reigned supreme until almost our own day. This ore looks certainly better that that, this fuel is finer than that one, as anybody can tell; that slag is all right, you can't see any metal in it; this pig iron is first quality, just look at the fracture—and so the rule-of-thumb man keeps on delivering dicta, drawn from experience, most of which are right and some of which are egregiously wrong.

The greatest benefactors of chemistry and metallurgy in the nineteenth century were those who developed analytical chemistry into a practical art—such as Berzelius and Fresenius, and those who led in its practical application, such as Bell, Bessemer, Muspratt and Lunge. It is surely unnecessary to give examples of what the analytical chemist has done for all branches of applied chemistry. He has been the principal factor in modern scientific control of all these operations; and the logic of this circumstance is so strong, that the chemist in the works laboratory has become the natural candidate for the superintendency of the plant.

The chemist in the laboratory is primarily a machine to do analytical work; but, granting him only moderate ability, he soon acquires incidentally such intimate insight into the *rationale* of the works' operations that he becomes indispensable out in the works as conductor of those operations.

The chemist should need no recommendation to modern technologists; they should all know by this time how hopeless it is to get along satisfactorily without him. But, there are still some adherents of rule of thumb who think they can; there still exist some foundrymen who believe they can tell good pig iron when they see it (but they cannot), steel workers who can tell the quality of steel from its fracture (they are often fooled completely by modern steels), blast-furnace men who can distinguish good coke from bad by the looks (retort-oven coke contradicts their experience), and so on, through all the range of chemical and metallurgical technology.

The modern way to get scientific control of this question of *quality* is to use the chemist, with his methods of examination—analytical, microscopic, experimental—and so keep going a works laboratory. If it does not pay for itself several times over, it will be through human imperfection in the laboratory or in the management of the works, but not to defect in the principle involved.

In any but large works the chemist will also be the physicist of the plant. He will be looked to to make those physical determinations of volumes, pressures, temperatures and heat distributions which are so badly needed, but so little employed. Incidentally, it may be observed that he is usually, by education and training, more fit to do this work than the mechanical engineer, who is often asked to perform it.

(3) The use of instruments to determine the volumes of gases involved in operating any process, is an improvement which tends away from rule of thumb and towards accurate control. The use of the anemometer to determine the volume of air-supply to a furnace, of the Pitot tube to measure the gas supply in a closed tube, of the draft gauge, plain or multiplying, to estimate resistances to flow and in general all the methods by which the volume and velocity of gas or air currents may be made known, are first aids to the scientific chemist or technologist.

Using forced draft it is possible to measure the delivery of a fan and adapt it exactly to the feed of coal dust so as to produce nearly perfect combustion: many a boiler gives poor results because twice as much air is used as is needed to burn the fuel, causing high chimney losses.

When managers realize, as they should, that such information means, if properly used, stopping of large leaks and obtaining of higher efficiencies, they will be quicker to avail themselves of the more accurate control thereby assured.

(4) In some operations, pressure plays an important part in the operation and should be accurately controlled by properly calibrated instruments. The back-pressure in a blast furnace is known indirectly by the increased work thrown on the blowing engines, but it is much better known by a suitably-placed gauge. An unexpected fall in pressure between two points on a blast main may indicate too small a main or an obstruction or high friction, which might be cured by making the interior smoother. If pressures are involved in any operation, an active use of the pressure gauge is a constant *desideratum*.

(5) Thermometry tells the intensity of heat effects and is being less and less neglected as the methods of pyrometry are being more and more perfected. Nothing is of more importance for any furnace process, than that the temperature conditions should be kept constant or be reproducible at will, and

...is instrumental determination of ...

...trained, can determine temperatures between a low red and a bright yellow with a considerable degree of accuracy, provided the eye is not fatigued and the pyrometer is kept in good working order. Good instruments however are more accurate, and are less susceptible to derangement or disorders, while they can be made to record a distance away, even to give a continuous record.

All these improvements have tended to remove empiricism and to replace it by accuracy, to take the control of the operation out of the hands or skill of the workman and vest it in the management of the work. Finally, it permits of high-priced skilled labor being supplanted by faithful, but less experienced and lower-priced men, all tending to greater regularity of output and lower cost of production. One of the most satisfactory developments in the last ten years has been the great increase in the number of reliable pyrometers and in their general use. That user of furnace processes who is not equipping his plant with pyrometers is surely allowing his competitor who does, to gain a great advantage.

In the metallurgy of iron, pyrometers have, until recently, been used only on the hot-blast main of the blast furnace. They should be used at the top of the furnace, at entrance to the stoves, at chimney flues and to control temperature of pig iron and slag. They should be used on mixers, puddling furnaces, open-hearth furnaces, bessemers, casting ladles, reheating furnaces, annealing furnaces, cementation and malleableizing furnaces, and for hardening and tempering.

In the metallurgy of copper they should be universally used to control the roasting operation and matting furnaces. In the metallurgy of zinc, the roasting and distilling furnaces will be under better control the more they are investigated pyrometrically.

Too high temperatures are often as greatly destructive as are low temperatures are inefficient, and both can be avoided or controlled by the pyrometers. Space forbids the cataloguing of even a fraction of the places and processes wherein pyrometry should be used more largely; it is one of the principle methods of controlling an operation in the hands of the modern technologist.

Last, calorimetry measures quantities of heat and tells in what directions the furnace is expending its energy. One boiler may evaporate 8 pounds of water per pound of coal, and another 10 pounds, but when we learn that the heat in the steam is only 40 and 50 per cent. respectively of the calorific power of the fuel, we first become aware of the great room still left for improvement.

Again, a steel-melting crucible delivers as useful heat in the melted steel only some 3 per cent of the calorific power of the fuel burned, an open-hearth furnace 25 per cent; a cupola 35 per cent; an electric furnace 50 to 75 per cent of the heat value of the electric energy expended. In all these cases, increase of the highest value to the metallurgist can only be attained by calorimetric measurements and calculations based thereon.

When a furnace process is thus analyzed thermally and the distribution of its available heat energy tabulated, so much to radiation, so much to imperfect combustion, so much to chimney loss and so much (usually *so little*) usefully applied, there becomes possible a true esoteric view of the operation.

Only in such broad grounds can the process be thoroughly understood in all its relations and such information opens the way to economies often unthought of before. We therefore plead earnestly for the pyrometer as one of the chemist's and metallurgist's most valuable, and perhaps most neglected, auxiliaries.

The conclusion of our argument is that technologists, in whose hands lies the application of science to human needs, should assist their endeavors and perfect their methods by the use of all the means of attaining *accuracy of control* which science furnishes them; that they should use and profit by the instruments of weighing and measuring masses, volumes, pressures, temperatures and heat; that they should use the analytical chemist more than ever before; and, finally, that by these means only can they reach the goal of the highest attainable efficiency.

The rule-of-thumb man guesses: the engineer calculates.

Jos. W. Richards.

The Iron and Steel Market.

The year 1906 has been by all odds the most prosperous one the American iron industry has ever enjoyed. In a few departments profits per ton have not been as great as in some other years, but tonnage has been very much larger. No previous year can at all compare in point of tonnage with 1906 except the year 1905, while the general level of prices was higher in 1906 than in 1905, although, except in pig iron, they did not reach an unhealthy level.

Production in 1906.

The total production of pig iron may be estimated as more likely to be over than under 25,300,000 tons, against 23,000,000 tons in 1905, a gain of an even 10 per cent. The year 1906 closes a decade in which but one year has failed to break all previous records for pig iron production. In 1897 and 1898 the gain in production was not accompanied by a sufficient gain in demand, and these two years saw the lowest prices ever recorded in the American iron trade. They will doubtless prove to be the lowest unless the monetary standard changes. A part of the advance in prices since then is really due to a lowering in the real value of the gold dollar. In 1899 demand suddenly recovered, and with a heavy gain in production prices nevertheless soared; 1900 saw a reaction in prices, with a slight gain in production; in 1901 and 1902 prices steadily rose, despite heavy increases in production; towards the close of 1903 a severe reaction set in, but the decreased production in the fourth quarter did not prevent the calendar year from showing a slight gain in production over 1902; the full force was felt in 1904. From towards the close of that year to the present time production and prosperity have been increasing hand in hand. Briefly, the course of pig iron production has been as follows: In 1897 a trifle under 10,000,000 tons, then a steady increase to about 18,000,000 tons in 1902 and 1903, a decline to 16,500,000 in 1904, and a gain to 23,000,000 in 1905, and to over 25,000,000 in 1906.

While pig iron is an excellent yardstick with which to gauge the production of commercially usable forms of iron and steel, it is a fact that production of the latter has increased somewhat more rapidly in recent years than production of pig iron. A careful estimate of the finished forms of the iron and steel trade, *i. e.*, of iron castings, steel castings and finished rolled iron and steel forms, shows that at present the tonnage is about equal to that of pig iron, the necessary loss of pig iron being fully made up by the use of scrap and of a small quantity of iron ore in the open-hearth process. The basic open-hearth process has in a very few years become a close second to the Bessemer in point of tonnage, and uses large quantities of scrap. The various processes for converting scrap into wrought iron, including puddling, knobbling, busheling, faggoting and piling on boards, decadent for many years, have taken on new life in the past three years. The iron mills, although using less than half a million tons of pig iron a year, are producing more than 2,000,000 tons of rolled products.

Prices in 1906.

A heavy buying movement at the close of 1905 left the iron trade but little to do in the early part of 1906 but get out tonnage. Prices were very steady—*i. e.*, for so fickle an industry—during the first half. Bessemer and basic pig iron and nearly all finished steel products were uniform in price throughout the half year. About March 1 iron bars had a

sharp drop, and about April 1 Northern foundry iron declined somewhat; in April, steel bars were shaded by one prominent producer, and in June occurred a sharp drop in Southern pig iron to $13, Birmingham.

Immediately after July 1 the whole complexion of affairs changed. In July foundry pig advanced slightly on light buying. In the first half of August the trade was startled by large purchases of Bessemer pig iron for delivery in the first half of 1907; in the second half of August foundry pig iron underwent the same movement. Thereafter all grades of pig iron advanced rapidly to famine prices. With the middle of September began a series of moderate advances in finished steel products, involving, by the end of the year, every finished steel product of importance except structural shapes and standard rails. Standard rails are a law unto themselves, having been maintained through thick and thin at $28 since the spring of 1901. Light rails, usually cheaper than standard rails, obviously from commercial rather than technical reasons, advanced to $33. Shapes had been advanced in August, 1905, at a time when other steel products were not being advanced, which probably accounts for their being an exception in this case.

A number of these advances have been in lines where it is the accepted trade usage for the mills to advance prices when a large tonnage has been entered, in order to protect contracts and induce specifying. Notable instances of these are merchant steel pipe and wire products. In these it may be possible to establish a lower level without disturbance to the general price fabric, but when pig iron declines, as ultimately it must, serious disturbance can scarcely be avoided. It is true that finished products have not been advanced by any means in proportion to pig iron, and the latter ought, therefore, to be allowed to decline by itself, but this theoretical argument was put forth in 1902 and 1903, and the outcome proved that the business world would not follow the theory. Pig iron reached up and dislodged finished steel prices.

THE CURRENT SITUATION.

The new year opens with substantially all the first-half pig iron output sold, and modest commitments being made for second half. More than half the year's rail output is sold, and the tonnage would undoubtedly be much larger were not many railroads waiting on open-hearth rails. Plates, shapes and steel bars are contracted for nearly the whole year, while in plates and bars specifications are actually assured for nearly six months' operation. In pipe, wire, sheets and tin plates absolutely certain business is booked for from three to six months. In all lines specifications are coming in freely

PIG IRON

It is useless to attempt in a brief space to give pig iron quotations accurately, since time of delivery and other considerations are all important. Southern No. 2 is about $23.00, Birmingham, for prompt, $21.00 to $22.00 for second quarter, $18.50 to $19.00 for third quarter only, and $18.00 to $18.50 for third and fourth quarters together. Northern No. 2 foundry, at valley furnace, is $25.00 for prompt, $22.50 to $23.00 for second quarter, $21.50 for third quarter, and $21.00 for second half. In these prices there is a tapering off, as to time of delivery, which will do much towards lessening the influence of the inevitable decline as production increases, since such an increase is well recognized as in prospect. Bessemer pig iron is $21.00 to $21.50 at furnace for second half.

PRICE ADVANCES.

Since last report the following advances have occurred:

Plates, $2.00 a ton to 1.70c., Pittsburg, for tank quality.

Splice bars, $3.00 a ton to 1.65c.

Wire products, $2.00 a ton to $2.00 a keg for nails and 1.85c for plain wire.

Light rails at Pittsburg, $1.00 a ton to $33.00 for 25 to 45-pound sections, in large lots; $34.00 in single carloads.

Merchant pipe, two separate advances of 1 point each.

FINISHED MATERIAL.

We repeat former quotations on the following:

Structural shapes on basis of 1.70c for beams and channels, 15 inches and under.

Merchant steel bars, 1.60c., base.

Sheets, 2.60c for black and 3.65c for galvanized, No. 28 gauge.

Tin plates, $3.90 for 100-pound cokes.

Sheet bars are about $30.00, Pittsburg. Billets are very scarce and quite irregular in price, being nominally about $29.50 to $30.00 for Bessemer, and $32.00 to $33.00 for open-hearth.

Faraday Society

ELECTROLYTIC PRODUCTION OF BLEACHING LIQUOR

At the November meeting of the Faraday Society two papers were presented dealing with electrolytic hypochlorite. Mr W. POLLARD DIGBY discussed "the depreciation of electrolytically produced solutions of sodium hypochlorite." This paper deals in the first place with depreciation taking place in bottles of various colors in which dark amber bottles gave the best results, the loss in 1,817 days being about 40 per cent for a solution containing 4.216 grms. of available chlorine per liter. The corrosive action of hypochlorite solutions upon various metals is then discussed, and the depreciations due to graphite, copper, zinc, lead and iron plates immersed in such solutions are set forth for a period of 480 hours. A much greater depreciation takes place, due to galvanic action, when two dissimilar metals immersed in the liquid are connected by an insulated wire; the paper gives records in the case of twenty-one different couples. When iron is present as one metal in such a couple, the depreciations are generally greater than for any two other metals.

As regards the area of the exposed surface in the cases of single metals immersed in hypochlorite solutions, it was found that doubling or trebling the surface doubled or trebled the rate of depreciation. Brief reference is made to the value of protective coatings as applied to metal couples, but no conclusive results were obtained.

As it is a matter of difficulty to paint evenly the inside of small plates, and, still more, of pipes, the writer deprecates reliance upon insulating materials for the protection of any vessel in which hypochlorite liquids are stored, or of any metallic piping in contact with hypochlorite liquids. When once the paint breaks down, corrosion of the metal will follow at a rapid rate. Accounts are also given of the value of bitumen as a protective agent for wood exposed to hypochlorite solutions.

In conclusion, the author urges that storage, transport and methods of conveyance from place to place, or even from one part of a factory to another, are details meriting attention. Certain conditions of storage may clearly be regarded as fatal to stability, particularly those in which the galvanic action of dissimilar metals is likely to arise.

Mr CHAS. V. BIGGS then presented a paper on "The Hermite Electrolytic Process at Poplar." This is a municipal plant, making a solution containing about 4.5 grams of available chlorine per liter, for use as a disinfectant in the boroughs.

The system adopted is to mix a certain quantity of fluid in an elevated tank, and then to allow this fluid to flow through four double troughs or cells, placed one above the other so that the liquid descends continuously by gravity. Each trough is divided laterally by a partition, and in each of the two divisions five distinct "elements" are suspended. The positive plates are of thin platinum wire wound upon slate slabs and the negative plates are of zinc. There are thus four troughs, each containing ten "elements," or forty cells in all. After passing through the successive cells the liquid discharges into a carboy. Sodium hydroxide is used as a preservative; it flows drop by drop into the carboy as it is filling, and serves to neutralize free

As the liquid passes through the troughs it is subjected to the action of a current of 15 amps. at 230 volts, being 5.6 volts per cell.

The tank is charged by placing in it 100 liters of a saturated solution of sodium chloride and 20 liters of a saturated solution of magnesium chloride. To this is added as much water as will bring the whole up to 840 liters. The rate of flow through the apparatus is 3 1-3 pints per minute.

Curves are appended showing (1) the rise in value of the solution as it passes through the cells, amounting to about 1 grm. per liter for 10 cells, (2) efficiency in grms. per B. T. U. for this plant, which is highest at a current of 16 amps. Above this amperage energy is wasted in heat, and below it the flow becomes too high.

A number of tests of samples of the liquid made are given. Liquid made during the warm weather of the exceptional summer of 1905, at a temperature of 104° F., was found to have lost only 0.1 grm. available chlorine per liter in six weeks. Several samples of liquid made before the conditions of the plant (as to mixing, rate of flow, etc.) were very fully determined, showed losses of 0.1 and 0.2 grms. per liter in six months, the higher strengths (4.8 to 5.3 grms. per liter) losing 0.5 grm. in six months.

The author concludes that the magnesium hypochlorite, as made at Poplar, is sufficiently stable for practical purposes, and that it could be made in a warm climate without necessarily rapid deterioration. The warm weather specimens quoted had been kept in ordinary dark glass bottles, merely corked.

Messrs. J. B. C. Kershaw, R. S. Hutton, L. A. Senart and W. Defries joined in the discussion. Mr. F. W. Alexander gave complete details regarding the cost of running the Poplar plant. The plant has been producing an average of 200 gallons a day of 0.4 grm. solution since January last, at a total cost for current and material of under $165. Two laborers suffice to watch the plant and bottle the solution. The defects of the original Hermite process have been successfully overcome. They have had no trouble with non-conducting films on the zinc cathodes. Non-stability is caused by the presence of undecomposed salt in solution. (See also p. 26.—Ed.)

Storage Batteries and Their Electrolytes.

At the December meeting a paper by Mr. R. W. Vicarey on this subject was presented. It is a continuation of one read by the author in July, 1905, and deals chiefly with some of the problems involved in the manufacture of accumulators, particularly as regards the effect of nitrogen and other impurities introduced consciously or by accident in the process of manufacture. Nitrogen compounds are often used, and advisedly so in the opinion of the author, for assisting in the oxidation of the positive plates, and in such cases it is essential that every trace of nitrogen be removed before the cells leave the works, in spite of the difficulties, which are insisted upon, involved in its complete elimination. The evils attributed to nitrogen, both after complete formation and in the latter stages of the forming processes, are described in detail.

Among other troubles the author has observed the formation of an irreducible and unoxidizable sulphate of lead $2PbSO_4 \cdot PbO$, a detailed study of the effects of which are promised for a future communication. The evil effects of nitrogen are greatly accentuated by the presence of other impurities—notably iron, an element likewise very difficult to eliminate—and experiments are described illustrating these effects, which become more serious with decreasing current densities. Researches of Peters, Elbs and Bell are quoted in support of the author's main contentions.

Mr. H. L. Joly criticised in detail many of the author's contentions. He could not accept the extreme "ammonia" theory claimed by the author, who had not furnished sufficient definite and reliable data to found hypotheses upon. He would like to have had an account of the physical constants of the "new" lead sulphate.

Theoretical Papers.

Two papers were presented by Dr. A. C. C. Cumming. This first paper was entitled "Contributions to the Study of Strong Electrolytes," and its first half dealt with the elimination of potential due to liquid contact.

Certain solutions have the property of reducing the potential due to the contact of two solutions, and potassium chloride has been used for this purpose. In most cases a saturated solution of potassium chloride does not remove all the diffusion potential; indeed, if the solutions in the cells be strong, it only removes a small part. This property of removing more or less of the diffusion potential depends on two factors in the connecting solution: firstly, the positive and negative ions must be of equal velocity; and, secondly, the concentration of the connecting solution must be high compared with the solutions in the cells.

The author suggests a saturated ammonium nitrate solution as that which fulfils these two conditions better than anything else at present known, and shows by experiments with different cells that this is the case.

A curious point was noticed when two cells containing the same solution, but of different concentrations, were joined by a third solution of the same substance. Whatever the strength of this third solution, the observed potential remained the same as when the two cells were directly connected with one another. This could have been predicted from Nernst's theory.

The second half of this paper gives the results of measurements of the c. m. f. between silver nitrate solutions of various strengths from 1/1000 normal up to ½ normal, three kinds of silver electrodes being used. The results prove that for silver nitrate the c. m. f. gives the same measure of the ionic concentrations as is obtained from the conductivities, and therefore support the view that the conductivity gives a true measure of the ionic concentration.

A second paper by Dr. A. C. C. Cumming deals with "The Electrochemistry of Lead." The tendency of any *ic* ion to be transformed into an *ous* ion with a lower valence may be measured by means of an oxidation electrode. A solution containing plumbic lead was obtained by dissolving PbO_2 in nitric acid, and the amount estimated analytically, while any desired strength of plumbous lead was obtained by addition of ordinary lead nitrate. The potentials were measured with a lead peroxide electrode, against a N calomel electrode, with a saturated ammonium nitrate solution as connection. The mean value for P; *i. e.*, the tendency $Pb^{\cdots\cdot} \rightarrow Pb^{\cdot\cdot}$, was found to be + 1.82 volt against the hydrogen standard electrode. The value for $Pb^{\cdot\cdot} \rightarrow Pb$ was also redetermined, and found to be — 0.137 volt, so that the value for $Pb^{\cdots\cdot} \rightarrow Pb$ is + 0.84 volt.

The results in general prove that lead in the tetrad form is a highly electropositive element, and also direct attention to a curious difference in the behavior of sodium and potassium nitrates towards lead nitrate.

CORRESPONDENCE.

Electric Smelting of Iron Ore.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—In your November issue you stated that the Northern Californian Power Co. were engaged in establishing a plant at this place for the reduction of iron ore by the Héroult process. In this you were mistaken, as Mr. H. H. Noble, president of that company, is solely interested in the undertaking, and the only interest that the power company has in the subject is in the creation of a large customer for electric power.

Work is actively progressing at this place in preparing ground for the plant, all of which has been ordered and will be installed early next year. Noble Electric Steel Co.

Héroult-on-the-Pitt, P. O. Baird, Shasta Co., Cal.

The Girod Ferro-Alloy Works and the New Girod Steel Furnace.

By DR. R. S. HUTTON.

A recent visit to the chief works at Ugine, in Savoy, of the Société anonyme Electrométallurgique. Procédés Paul Girod and the courtesy of the director of this company in supplying photographs and information have enabled the following brief account to be prepared for the readers of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY. The company at the present time possesses three important works, viz.: at Ugine, in

FIG. 1.—THE GIROD WORKS AT COURTEPIN, SWITZERLAND

Savoy, at Courtepin and at Montbovon, in Switzerland. A total of 18,000 hp. is in use, but the harnessing of further power is rapidly progressing, and shortly some 45,000 hp. will be available.

The history of the development of these large works follows the lines which have been so characteristic of many of our most important electrochemical industries. Starting in 1898 with a small experimental plant of only 28 hp., Monsieur Paul Girod attacked and gradually overcame the great difficulties underlying the production of high-grade ferro-alloys. In 1899 a works employing 1,000 hp. was started at Albertville, and with accumulating experience still more ambitious schemes were planned and executed. The great success which this company has had may, doubtless, in some measure, be attributed to the foresight of its director and to the fact that this early experience was quickly applied so soon as the development of rapid-cutting tool steels and other special steels created a demand for ferro-alloys.

At the end of November, 1903, the works at Courtepin (see Fig. 1) were started with 1,800 hp., which has been rapidly increased to 5,000 hp., the power being obtained at 16,000 volts from the Fribourg Cantonal Government. In the same year the water rights of the falls of the Arly were purchased, and the installation of the power plant of 8,500 hp. at Ugine was completed in a remarkably short space of time, being available for use in December, 1904.

INSTALLATION AT UGINE.

The French Alps offer many surprises to those unfamiliar with the remarkable hydro-electrical installation in this part of the European continents. The valley of the Arc in its descent from Modane to Saint Michel with its four large aluminium works and numerous other smaller factories; or the valley of the Romanche, near Grenoble, with carbide and ferro-alloy works, both form centers of electrochemical industry which are already comparatively well known. Even in these cases the rapid changes which have recently been effected and the enormous developments which are in progress cannot fail to impress those who have closely followed the trend of electrochemical work in this part of the world.

In the beauty of its surroundings and in the evidence which is forthcoming of extensive and successful development, the works at Ugine (see Fig. 2) are, however, almost unsurpassed. Situated at the foot of snow-clad mountains in a peaceful valley, almost luxuriant in its vegetation, the contrast with the more usual surroundings of works connected with the iron and steel industry is very marked. The fall available is 125 meters, the water being conveyed from the *barrage* through a tunnel of 3 kilometers, and then by two steel conduits each of 1.32 meters diameter and 550 meters length.

The power house, 120 meters long and 10 meters broad, shown in Fig. 3, contains nine 600-hp. and nine 300-hp. Neyret Brenier turbines, driving six 600-hp. and nine 300-hp. continuous-current machines, and three 600-hp. alternators. The furnace house runs parallel with that in which the machines are installed, and is equipped with a large number of special furnaces of the "smothered-arc" type, provided with automatic regulation, efficient ventilation and all the equipment necessary for successful and continuous working

Auxiliary plant, such as crushing and grinding machines and mixers, is also plentifully available.

PRODUCTS OF THE WORKS.

The present annual output of the three installations, so far as the chief products are concerned, may be summarized as follows:

5,000 tons ferro-silicon, 50 per cent.
1,000 tons ferro-silicon, 30 per cent.
2,000 tons ferro-chromium.
800 to 900 tons ferro-tungsten.
About 50 tons ferro-molybdenum.
5 to 10 tons ferro-vanadium.

The total value of the alloys sold being at the present time

FIG. 2.—FERRO-ALLOY WORKS AT UGINE

equivalent to over 9,000,000 francs per annum. These figures alone convey some idea of the magnitude of the undertaking.

As is well known, the Société specializes largely in high-grade alloys of low carbon content, some typical analyses of these products are given below. These alloys find a ready sale, not only in France where the development of "ternary" and "quaternary" steels has had an earlier development than in most other countries, but also in Germany, Austria and England, and even in America amongst the leading steel firms.

Of special interest are the ferro-tungsten and ferro-molyb-

[illegible] account largely for the high value of the pro[illegible] works. The ferro-tungsten can be classed in two [illegible] containing about 85 per cent W, and a [illegible] per cent carbon, is chiefly employed in the [illegible] of crucible tool steels. The other quality, con[illegible] per cent W and 2-3 per cent C is largely used for [illegible] the open hearth process of steels containing [illegible] W, which are used for the manufacture of [illegible]

FIG. 3.—POWER HOUSE OF THE UGINE WORKS.

In both cases considerable advantage and economy are claimed over the tungsten powder which is still largely used in steel making. For assuring the most satisfactory conditions of manufacture the company has recently acquired extensive wolfram mines at Guarda, in Portugal and Puy-les-Vignes, in the province of Haute-Vienne.

ANALYSIS OF TYPICAL PRODUCTS.

	Ferro-Chromium.			
Cr	67.20	64.17	67.05	65.90
Fe	31.35	32.47	27.05	23.44
C	0.90	2.34	4.25	8.58
Si	0.19	0.38	0.60	1.26
Mn	0.12	0.21	0.46	0.44
Al	0.00	0.13	0.22	0.18
Mg	0.19	0.23	0.31	0.14
S	0.000	0.023	0.02	0.02
P	0.021	0.02	0.02	0.02
	Ferro-Tungsten.			
W	85.15	71.80		
Fe	14.12	24.35		
C	0.45	2.58		
Si	0.13	0.36		
Mn	0.085	0.78		
P	0.018	0.008		
S	0.021	0.02		
	Ferro-Molybdenum.			
Mo	79.15	83.80		
Fe	17.52	12.72		
C	3.24	3.27		
S	0.021	0.02		
P	0.028	0.027		
	Ferro-Vanadium.			
V	52.80	34.10		
Fe	45.84	64.22		
C	1.04	1.42		
Si	0.09	0.12		
Al	0.00	0.00		
S	0.025	0.03		
P	0.02	0.009		

THE GIROD STEEL FURNACE.

The ingenious and interesting crucible furnace devised by M. Girod and already described in this journal (Vol. II., p. 300), has been abandoned so far as its application to the manufacture of steel is concerned. On the other hand, a furnace has been constructed and submitted to the test of extensive use which seems destined to play a not unimportant part in the inevitable extension of manufacture of steel by electrical heating processes.

This furnace is of the arc type and is characterized by the fact that it employs a single vertical electrode. The arc is maintained between this electrode and the slag which covers the metal contained in the hearth of the furnace. The molten metal is connected to the other pole of the dynamo by means of a series of water-cooled steel bars sunk in the refractory lining of the base of the hearth.

The process of treatment is in general similar to that adopted in the Héroult furnace; the superposed layers of slag being of such a composition as is required for the refining or carburization of the metal, and being renewed from time to time to assist in these processes.

The photograph of the furnace, shown in Fig. 4, does not represent it in its most recent modification, the cover or dome being now of an improved type which ensures a more complete enclosure of the furnace. The power in the present case is 300 to 350 hp., and the charge is from 1.2 to 1.5 tons.

Extensive trials have already been effected, notably by one of the leading French steel works, which has been utilizing the equipment at Ugine for the manufacture of a special steel for the construction of small pieces of armor plate, etc.

So far as can be seen the power expenditure is quite favorably low; and the possibility of eliminating the injurious constituents from the low-grade steel charged into the furnace offers no more difficulty than is the case with those furnaces which employ two electrodes arcing into the slag.

FIG. 4.—THE GIROD STEEL FURNACE.

In the simplicity of the design and in the case with which automatic regulation can be effected, the present furnace is certainly of considerable interest.

In the annex of the works in which this steel plant has been erected, M. Girod is also employing one of his resistance furnaces as a re-heating furnace for small steel ingots. The heating chamber of one of his multiple crucible furnaces contains the ingots to be heated, the chamber itself being surrounded by the resistance material, consisting of ferro-silicon and carbon. This type of reheating furnace is certainly worthy of consideration, for in few applications of fuel heating is the waste of coal so enormous as in the old-fashioned reheating furnaces still so largely employed in the steel industry.

Metallurgical Calculations.

By J. W. Richards, Ph. D.
Professor of Metallurgy in Lehigh University.

THE TEMPERATURE INCREMENT IN THE BESSEMER CONVERTER.

In our preceding paper (this journal, December, 1906) we have studied the generation of heat in the Bessemer converter, and its distribution. We saw in that analysis that in a typical operation, nearly one-half of the heat generated during the blow is carried out by the hot gases, about half is represented in the increased temperature of the contents of the converter, while only about 5 per cent is lost by radiation, etc. In the present paper we wish to analyze still further this question of increased temperature, which is so vitally necessary for the proper working of the process, and to calculate the relative efficiency of the various substances oxidized in causing this rise of temperature.

While at no time in the Bessemer operation is only one substance being oxidized, yet we can get the best basis for our computations by assuming a charge in operation and only one substance oxidized at a time. Whatever substance is in question, let us assume one kilogram burnt in a given short period of time, generating the heat of its combustion. With the bath at a given temperature, the air, at say 100° C., comes in contact with it, bearing the necessary oxygen. If nothing was oxidized, the oxygen and nitrogen would simply be heated to the temperature of the bath, and pass on and out, while the bath would be meanwhile losing heat also by radiation. It is evident then, that unless at least as much heat as the sum of these two items is generated, the bath will cool, and that only the excess of heat above this requirement is available for increasing the temperature of the bath and resulting gases. The proper procedure for us will therefore be to calculate, in each case, the chilling effect of the air entering, subtract this from the heat generated, and the residue is net heat available for raising the temperature of the contents of the converter and the gases, and supplying radiation losses. The latter are proportional to the time, and therefore to the amount of air used, assuming blast constant.

Silicon.

This is burnt out in the first part of the process, during which the temperature begins low and ends high. We will therefore assume two temperatures, and calculate the thermal increment at each. We will take 1250° and 1600°. The net heat is absorbed by the bath, slag and nitrogen.

Oxygen necessary to burn one kilogram of silicon
$1 \times 32/28 = 1.143$ kg.
Nitrogen accompanying this oxygen = 3.810 "
Weight of air needed = 4.953 "
Volume of air = 4.953 ÷ 1.293 = 3.831 m³
Specific heat, 100° to 1250°, per m³ = 0.3395
Specific heat, 100° to 1600°, per m³ = 0.3489
Chilling effect of air at 100°, bath at 1250°
= 3.831 × 0.3395 × 1150 = 1496 Cal.
Chilling effect of air at 100°, bath at 1600°
= 3.831 × 0.3489 × 1500 = 2043 Cal.
Heat generated per kilogram of silicon = 7000 Cal

This is, however, for cold oxygen and cold silicon burning to cold solid silica. Under the conditions prevailing we have melted silicon at the temperature of the bath, oxidized by hot oxygen to hot silica, giving a slightly different heat of combination, calculated as follows:

Heat in melted silicon at 1250° = 480 Cal.
" oxygen required, at 1250° = 334 "
" silica, at 1250° = 750 "
Heat of oxidation at 1250°
= 7,000 − 480 − 334 − 750 = 7,064 "

The difference from 7,000 is so small as to be within the possible error of the 7,000 itself, and we can therefore make the calculations with all the accuracy they allow, taking the ordinary heats of oxidation from the tables.

One factor of heat generation has, however, not been mentioned, viz.: the heat of combination of silica with oxides of iron and manganese to form slag. This is 148 Calories per kg. of silica when forming iron silicate, and 90 when forming manganese silicate, which quantities would become 317 and 193 Calories respectively when calculated per kg. of silicon oxidizing. The question arises, however, whether it is fair to credit all this to the silica, because this generation of heat by slag formation is really a mutual affair, chargeable to the credit of both silica and the other oxides; we should, therefore, not charge it all up to the credit of silica formation, and we do not know what part to charge to the credit of silica if we do not charge it all. In this dilemma it may be well to remember that silicon is probably oxidized before the iron and manganese, and that the heat of formation of the slag is therefore more properly considered as being generated afterwards, and therefore may be practically credited entirely to the oxidation of iron and manganese.

Resumé for oxidation of 1 kilo. of silicon:

	Cal.
Heat generated	= 7,000
Chilling effect of the blast, 100° to 1250°	= 1,496
Chilling effect of the blast, 100° to 1600°	= 2,043
Available heat, bath at 1250°	= 5,504
Available heat, bath at 1600°	= 4,957

If we assume a radiation loss proportional to the length of the blow, *i. e.*, proportional to the air blown in, we can find out from average blows that this amounts to about 50 Calories per cubic meter of blast used. The radiation loss during combustion of 1 kilogram of silicon would therefore be

	Cal.
3.831×50	= 192
Leaving net available heat at 1250°	= 5,312
At 1600°	= 4,765

The above quantity of heat is expended in raising the temperature of 99 kg. of bath, 2.143 kg. of silica, and 3.810 kg. of nitrogen gas, from their initial temperature. At the temperatures of 1250° and 1600°, respectively, the heat capacity of these products of the operation will be, per 1° C. rise:

Products.	*Specific Heat* at 1250°	at 1600°	*Heat Capacity* at 1250°	at 1600°
Bath, 99 kg.	0.25	0.25	24.8	24.8
SiO^2, 2.14 kg.	0.37	0.43	0.8	0.9
N^2, 3.02 m³	0.37	0.39	1.1	1.2
		Totals.	26.7	26.9

Theoretical rise of temperature
5,312 ÷ 26.7 = 199° (bath at 1250°)
4,765 ÷ 26.9 = 177° (bath at 1600°)

Average rise, per average 1% of silicon = 188° C.

Manganese.

As high as 4 per cent of manganese may be oxidized during the blow, and therefore this heat of combustion is sometimes important. We will calculate the net heat available for raising temperature and the rise of temperature per 1 per cent of manganese oxidized, *i. e.* for 1 kilo. of manganese per 100 kilos. of bath.

Oxygen necessary 1 × 16/55 = 0.291 kg.
Nitrogen accompanying this = 0.970 "
Weight of air used = 1.261 "
Volume of air used = 0.975 m³
Chilling effect of air at 100° on bath at
1250° = 0.975 × 0.3395 × 1150 = 381 Cal.

[illegible] kg. manganese	= 1053	"
Heat of formation of $MnO.SiO^2$		
1.29 kg. MnO	= 98	"
1.56 kg. SiO^2	= 1751	"
Heat available = 1751 − 381	= 1370	"
Radiation loss = 0.975 × 50	= 49	"
Net available heat	= 1321	"
Heat capacity of 99 kg. of bath per 1°	= 24.8	"
Heat capacity of 2.4 kg. of slag	= 0.7	"
Heat capacity of 0.8 m³ of nitrogen	= 0.3	"
Heat capacity of products per 1°	= 25.8	"

Theoretical rise of temperature:

$$1321 \div 25.8 = 51° \text{ C}$$

Giving, in round numbers, one-fourth the efficiency of silicon.

Iron.

While it is not desired to oxidize iron, and while it is relatively less oxidizable than silicon or manganese, yet some is always oxidized because of the great excess of iron present in the converter. The amount of iron thus lost is variable, and some of it, towards the end of the blow, may be oxidized to Fe^2O^3 instead of FeO, the larger part, however, oxidizes to FeO. We will make the calculations for both oxides, per kilogram of iron.

Formation of FeO.

Oxygen necessary 1 × 16/56	= 0.286	kg.
Nitrogen accompanying this	= 0.953	"
Weight of air used	= 1.239	"
Volume of air used	= 0.958	"
Chilling effect of air at 100° on bath at 1250° = 0.958 × 0.3395 × 1150	= 374	Cal.
Chilling effect of air at 100° on bath at 1600° = 0.958 × .3489 × 1500	= 501	"
Heat generated per kg. of iron	= 1,173	"
Heat of formation of FeO.SiO^2 = 1.28 kg. FeO × 124	= 159	"
Total heat developed	= 1,332	"
Net heat available at 1250° = 1332 − 374	= 958	"
Net heat available at 1600° = 1332 − 501	= 821	"
Radiation losses = 0.958 × 50	= 48	"
Net available heat at 1250°	= 910	"
Net available heat at 1600°	= 773	"
Heat capacity of 99 kg. of bath per 1°	= 24.8	"
Heat capacity of 2.4 kg. of slag per 1°	= 0.7	"
Heat capacity of 0.8 m³ of nitrogen	= 0.3	"
Heat capacity of products per 1°	= 25.8	"

Theoretical rise of temperature:

$$910 \div 25.8 = 36° \text{ C}$$

$$773 \div 25.8 = 30° \text{ C.}$$

Thus only about five-sixth as efficient as silicon.

Formation of Fe^2O^3.

Weight of air used	= 1.859	kg.
Volume of air used	= 1.438	m³
Chilling effect of air at 100° on bath at 1600° = 1.438 × 0.3489 × 1500	= 753	Cal.
Total heat developed by oxidation	= 1746	"
Heat of formation of slag	= 159	"
Total heat developed	= 1905	"
Heat available = 1905 − 753	= 1152	"
Radiation losses = 1.438 × 50	= 72	"
Net heat available	= 1080	"
Heat capacity of products	= 26	"

Theoretical rise of temperature:

$$1080 \div 26 = 42° \text{ C}$$

Titanium.

While titanium is an unusual constituent of pig iron, yet it is conceivable that titaniferous pig iron might be made and blown to steel. The following calculation, based on an estimated but quite probable value for the heat of oxidation of titanium, will show that the titanium is a valuable heat producing substance, being, in fact, weight for weight three-fourths as efficient as silicon.

Oxygen needed 1 × 32/48	= 0.667	kg.
Nitrogen accompanying this	= 2.222	"
Air used	= 2.888	"
Volume of air needed	= 2.250	m³
Chilling effect of air at 100° on bath at 1250° = 2.250 × 0.3395 × 1150	= 878	Cal.
Heat generated per kg. of Ti (probably)	= 5000	"
Heat of formation of slag—unknown.		
Net heat available = 5000 − 878	= 4122	"
Deduct for radiation losses	= 3978	"
Heat capacity of products per 1° C.	= 26.5	"

Theoretical rise of temperature:

$$3978 \div 26.5 = 150° \text{ C.}$$

Aluminium.

This metal is also rarely found in pig iron, yet when present it would be a powerful heat producer, as the following calculations show:

Oxygen needed 1 × 48/54	= 0.889	kg.
Nitrogen	= 2.903	"
Air	= 3.852	"
Volume of air	= 2.964	m³
Chilling effect of air at 100° on bath at 1250° = 2.964 × 0.3395 × 1150	= 1157	Cal.
Heat generated per kg. of Al	= 7272	"
Heat of formation of slag—uncertain.		
Heat available = 7272 − 1157	= 6115	"
Deducting for radiation losses	= 5967	"
Calorific capacity of products per 1° C.	= 26.6	"

Theoretical rise of temperature:

$$5967 \div 26.6 = 224° \text{ C.}$$

If a blow was running cold, and ferro-silicon was not on hand to add in order to increase its temperature, ferro-aluminium, or aluminium itself, would be a good substitute in the emergency.

Nickel.

It is hardly probable that nickeliferous pig iron would be blown to steel, because of the waste of valuable nickel in the slag; yet if 1 per cent of nickel were thus oxidized, calculations similar to the preceding would show a net rise in temperature of the contents of the bath of about 33° C.

Chromium.

Quite recently some chromiferous pig iron has been blown in the Bessemer converter, and those in charge were hampered by the lack of data as to how chromium would behave during the blow and its heat value to the converter. Technical literature has not yet been enriched by the account of the experiences, and no thermo-chemist has, as yet, determined the heat of oxidation of chromium or of formation of chromium slag. From what we know of the chemical reactions of chromium, however, it is likely that its heat of oxidation is somewhere about 3,000 Calories per kilogram. Using this, and neglecting the heat of formation of slag, we have the following approximation to its heating efficiency, assuming it to be oxidized when the bath is near to its maximum temperature:

Oxygen needed 1 × 48/104	= 0.462	kg.
Nitrogen entering	= 1.540	"
Air used	= 2.002	"
Volume of air	= 1.548	m³
Chilling effect of air at 100° on bath at 1600° = 1.548 × 0.3489 × 1500	= 810	Cal.
Heat of oxidation (assumed)	= 3,000	"
Net heat = 3000 − 810	= 2,190	"
Deducting for radiation losses	= 2,113	"
Calorific capacity of products per 1°	= 26.1	"

Theoretical rise of temperature:

$$2{,}113 \div 26.1 = 81 \text{ C.}$$

CARBON.

This element commences to be oxidized in large amount only towards the middle of the blow, when the temperature of the bath is high, because of the previous oxidation of silicon. It will be about right, therefore, to estimate the bath at an average temperature of 1600 during the elimination of carbon. The product is mostly CO, but partly CO^2. We will, therefore, calculate for each of these possible products separately. The net heat available, after allowing for average radiation losses, is used to increase the temperature of the products, *i. e.*, of the bath, the nitrogen and the CO or CO^2.

Oxidation to CO.

Oxygen required = 1 × 32/12	= 2.667	kg.
Nitrogen accompanying	= 8.889	"
Air used	= 11.556	"
Volume of air	= 8.937	m^3
Chilling effect of air at 100° on bath at 1250° = 8.937 × 0.3395 × 1150	= 3.489	Cal.
Heat of oxidation	= 8,100	"
Heat available = 8,100 — 3,489	= 4,611	"
Radiation losses = 8.937 × 50	= 447	"
Net heat available	= 4,164	"
Heat capacity of 99 kg. bath = 99 × 0.25 =	24.80	"
Heat capacity of 7.05 m^3 N^2 = 7.05 × 0.37 =	2.61	"
Heat capacity of 1.90 m^3 CO^2 = 1.90 × 0.88 =	1.70	"
Heat capacity of products, per 1° C. =	29.11	"

Theoretical rise of temperature:

$$4{,}164 \div 29.11 = 143 \text{ C.}$$

Since carbon burns to CO^2 principally at the beginning of the blow, while the bath is cold, we see that carbon thus consumed is about three-quarters as efficient as an equal weight of silicon in raising the temperature of the bath.

Oxidation to CO.

Oxygen needed 1 × 16/12	= 1.333	kg.
Nitrogen accompanying	= 4.444	"
Air used	= 5.777	"
Volume of air	= 4.469	m^3
Chilling effect of air at 100° on bath at 1600° = 4.469 × 0.3489 × 1500	= 2,339	Cal.
Heat of oxidation	= 2,430	"
Heat available = 2,430 — 2,339	= 91	"
Radiation losses = 4.469 × 50	= 233	"
Net heat available = 91 — 233	= —142	"
Heat capacity of 99 kg. of bath = 99 × 0.25 =	24.8	"
Heat capacity of 3.5 m^3 of N^2 / Heat capacity of 1.9 m^3 of CO = 5.4 × 0.39 =	2.1	"
Heat capacity of products	26.9	"

Theoretical rise of temperature:

$$-142 \div 26.9 = -5 \text{ C.}$$

The result is, therefore, that when carbon burns, as it mostly does, to CO, and the temperature of the bath is high, there is practically no further rise of temperature, for the heat of oxidation is barely sufficient to counteract the chilling effect of the air and to supply radiation and conduction losses.

In the above calculations, no allowance was made for heat required to separate carbon from its combination with iron, or for the variation in the heat of combination of carbon with oxygen from the combination heats at ordinary temperatures. The former is not known, or perhaps is very nearly zero. The heat of oxidation of liquid carbon at 1250° to CO^2 or at 1600° to CO is calculated as follows:

Oxidation 1 kg. C to CO^2 at 0°	= 8,100	Cal.
Heat to raise 1 kg. C to 1250°	= 505	Cal.
Heat to liquefy 1 kg. at 1250°	= 129	"
Heat to raise 2.67 kg. O^2 to 1250°	= 779	"
Heat to raise reacting substances to 1250°	= 1,413	"
Heat in 3.67 kg. CO^2 at 1250°	= 1,493	"
Heat of reaction at 1250° (8,100 + 1,413 — 1,493)	= 8,020	"

For production of CO, at 1600°, the correction is larger, as is seen from the following:

Oxidation 1 kg. C to CO at 0°	= 2,430	Cal.
Heat to raise 1 kg. to 1600°	= 680	Cal.
Heat to liquefy 1 kg. C at 1600°	= 156	"
Heat to raise 1.33 kg. O^2 to 1600°	= 554	"
Heat to raise reacting substances to 1600°	= 1,390	"
Heat in 2.33 kg. of CO at 1600°	= 1,104	"
Heat of reaction at 1600° (2,430 + 1,390 — 1,104)	= 2,716	"

The use of this corrected value makes the oxidation of C to CO give a small net heat development, with consequent slight rise of temperature, instead of the slight cooling effect before calculated. The conditions are so nearly even, however, that a slight increase of temperature or slowing up of the blow would wipe out the heat excess.

PHOSPHORUS.

This is the last important element to be considered, and is always eliminated after the carbon, at the maximum bath temperature, which we will assume, for calculation, at 1600°. The heat generated, at ordinary temperatures, is 5892 Calories per kilogram of solid phosphorus. Per kilogram of liquid phosphorus it would be only 5 Calories more, or 5897 Calories. For the reaction at 1600° we would have a different value, probably some 500 Calories more, but the necessary data concerning the specific heats of P and P^2O^5 are not known, and we must omit this calculation. The heat of combination of iron and phosphorus is also a doubtful quantity. Ponthiere places it as high as 1,397 Calories per kilogram of phosphorus, but this appears altogether improbable, since another experimenter could obtain no heat of combination at all. As concluded in another place, I advise for the present omitting this questionable quantity.

The phosphorus pent-oxide forms $3CaO \cdot P^2O^5$ with the lime added, but since there is always more lime present than corresponds to these proportions ($3CaO : P^2O^5 :: 168 : 142$), the calculation of heat of formation of the slag must be based on the amount of P^2O^5 formed (1123 Calories per kilogram of P^2O^5). This amounts to a considerable item. On the other hand, the lime needed for slag is put in, usually preheated, for the sole purpose of combining with the P^2O^5. It seems, therefore, only right to charge the phosphorus with the heat required to raise this lime to the temperature of the bath. The lime added averages three times the weight of P^2O^5 formed, and is preheated usually to about 600°. Assuming these conditions, the following calculations can be made per kilogram of phosphorus oxidized:

Oxygen required	= 1.29	kg.
Nitrogen accompanying	= 4.30	"
Air used	= 5.59	"
Volume of air	= 4.32	m^3
Heat of formation of slag, 2.29 kg. P^2O^5 × 1123	= 2572	Cal.
Heat of oxidation of phosphorus	= 5897	"
Total heat developed	8469	"
Chilling effect of air at 100° on bath at 1600° = 4.32 × 0.3489 × 1500	= 2261	"
Chilling effect of lime (600° to 1600°) (2.29 × 3) × 0.328 × 1000	= 2255	"
Chilling effect of blast and lime	= 4514	"
Heat available = 8469 — 4514	= 3955	"
Radiation losses = 4.32 × 50	= 216	"
Net heat available	3739	"
Heat capacity 99 kg. of bath = 99 × 0.25	= 24.8	"
Heat capacity 3.4 m^3 of N^2 = 3.4 × 0.30	= 1.3	"
Heat capacity 6.9 kg. of slag = 6.9 × 0.3	= 2.1	"
Heat capacity of products, per 1°	= 28.2	"

Heat effect of oxidizing 1 kilogram of element.

	Heat of Oxidation.	*Formation of Slag.*	*Total Heat Developed.*	*Chilling Effect of Blast, Radiation, etc.*	*Net Heat Available for Raising Temperature.*	*Theoretical Rise of Temperature.*
Silicon	7,000	.....	7,000	1,688	5,312	188°
Manganese	1,053	98	1,751	430	1,321	51°
Iron (to FeO)	1,173	159	1,332	422	910	33°
Iron (to Fe_3O_4)	1,746	159	1,905	825	1,080	42°
Titanium	5,000	....	5,000	1,022	3,978	150°
Aluminum	7,272	.....	7,272	1,305	5,967	224°
Nickel	1,051	159	1,210	378	832	33°
Chromium	3,000	....	3,000	887	2,113	81°
Carbon (to CO_2)	8,100	.....	8,100	3,936	4,164	143°
Carbon (to CO)	2,430	.....	2,430	2,572	—142	—5°
Phosphorus	5,807	2,572	8,469	2,477 (2,253*)	3,739	133°

* Chilling effect of lime added, preheated to 600°.

It must be observed that the above table is for comparison only, it cannot be used for an actual case, such as when 1 per cent of silicon, 3 of iron, 4 of carbon and 2 of phosphorus are oxidized. In such a case, the rise in temperature would be only very roughly:

From silicon	1	× 188 =	188°
From iron	3	× 33 =	99°
From carbon		say =	0
From phosphorus	2	× 133 =	266
		Total =	553° C.

It is to be recommended that in each specific case the calculation be made for the specific conditions obtaining, such as temperature of the metal at starting, temperature of the blast, time of the blow (as far as this affects radiation and conduction losses), proportion of carbon burned to CO^2, free oxygen in the gases, moisture in the blast, temperature and quantity of lime added, corrosion of lining. When all these items and conditions are taken into account there will be room for only small discrepancy between the calculated and the observed rise of temperature. The chief items needing experimental research at present are: The specific heat of the melted bath, the specific heat of the slag, the heat of combination of various elements comprising the bath, the heat of formation of the slag, and the heat of oxidation of some of the rarer elements, such as titanium and chromium. Such establishments as the Carnegie Institution could not do the cause of metallurgy better service than to subsidize metallurgical laboratories for the determination of such data.

Western Association of Technical Chemists and Metallurgists. The second general meeting of this Association was held in Salt Lake City, Utah, from Dec. 27 to 29, 1906. The program contains the following papers: F. W. Traphagen, on the slag or matte problem; F. A. Thomson, on a sampling apparatus for metallics; S. Rickard, on an electric method of preventing boiler scale; F. Leonard, on evaniding practice at Copper Queen mines; H. C. Parmelee, on the determination of sulphur in pig iron. Numerous visits and excursions to metallurgical plants were also on the program.

Modern Gold Milling.

By George P. Scholl, Ph. D.

Within recent years there have been a great many changes in the construction of mill buildings, and the progress made in the structural and engineering features is quite remarkable. The modern mill already in its exterior appearance clearly shows the change which has taken place. Instead of the ramshackle, hastily put up structures which were so much in evidence during former years, and which showed plainly that they were only put up in the cheapest possible manner and with hardly any thought to permanency, we now see well-designed buildings.

In the more modern of mill buildings structural iron has replaced wood almost altogether, and in some of the modern plants the use of iron has been carried so far that even the mill bins and the elevator casings are constructed of sheet iron. Amply lighted and well ventilated and with sufficient room allowed for the inspection and accessibility of the machinery, these mills bear evidence that they were put up in a substantial manner, and with a view to secure ease of supervision.

The interior aspect of a modern mill is also altogether different from one of the older type. It does no more present the aspect of a lumber yard, it has no shaky floors and unsubstantial foundations, and no apparatus are stuck away in corners without any regard being paid to their accessibility for supervision and repair.

With its substantial cement floors, its solid mortar foundations, it shows clearly that it is intended to facilitate operations in every possible respect, and to fulfill the purpose for which it was built, namely, to treat large masses of low grade ore as cheaply as possible.

There is no doubt that in the mining industry the future does not belong to the comparatively small quantities of bonanza ore but to the large masses of low grade propositions. This change in the aspect of the mills typifies the change in the whole system of metallurgy, because these low grade propositions have to be worked along scientific lines, and every possible item of value has to be saved, so that the slipshod methods employed at the older mills, where very frequently nobody seemed to care how much gold and other values were lost in the tailings, can no longer be employed.

Modern mill practice, therefore, differs essentially from that which was prevalent even a few years ago. The writer has recently had occasion to visit a large number of modern mills, and it was extremely interesting to notice the changes which have taken place.

In the modern plants a good deal of attention is being paid to securing good and substantial foundations for the apparatus, and especially the stamp batteries. Liberal use is made of concrete for this purpose, and the foundation work is sometimes very costly, but the increase in cost is more than made up for by the solidity and freedom from jarring and vibration of the building. In regard to the battery foundations, modern tendencies are overwhelmingly in favor of the concrete foundation. The prejudice which unquestionably existed in the mind of many managers, even men of wide experience in stamp mill practice, against the concrete foundations, seems to be fast disappearing, although it is by no means altogether overcome.

It is quite true that the opponents of the concrete foundation could point to instances where the foundations had not given satisfaction, but the greater part of the trouble was undoubtedly caused by the unfamiliarity of the men who built the foundation, with the kind of material required for this work, and perhaps their unfamiliarity with concrete work in general. It is not always easy in far-away mining regions to secure men particularly fitted for carrying out a delicate job of work which requires care and attention, as concrete work undoubtedly does, and the tendencies to carelessness in the working of the material and the proper mixing and proportioning of the ingredients are

always present. Moreover, a good deal of care is required in getting the battery mortars to bear evenly with their lower surface on the top of the concrete foundation, and any neglect in this regard is apt to lead to disastrous results.

The interposition of a sheet of rubber to cushion the blow is, of course, an additional safeguard in this respect, but it is much more advisable to pay careful attention to the leveling of the top of the foundation and to use a comparatively thin sheet of rubber than to rely upon a thicker intervening layer. A well-built concrete foundation is sure to last indefinitely, and to cause much less trouble than a wooden foundation, which latter is undoubtedly the weakest point in the battery, and a source of considerable trouble when it needs repairs and renewals.

A point to which particular attention should be paid in the construction of concrete foundations is that the proper amount of cement should be allowed in the mixture. This is one of the instances where it does not pay to save on the cement and use too high a proportion of inert materials. It should always be remembered that the cement is the only material that holds the concrete together and gives strength to the mixture, and that a structure which is so much subjected to vibration and strains as a battery foundation is needs to have considerable strength.

The tendency of course to cheapen the cost of the concrete by decreasing the amount of cement is always present, especially when the work is done by independent contractors. One instance of such a procedure came to the notice of the writer, where the battery foundation had cracked on account of the poor material used by the contractor and had to be largely replaced. In this instance the contractor had deliberately and by collusion with an employee who was supposed to watch the work, disregarded the proportions specified in the contract, and had used a much smaller proportion of cement. Such occurrences are, however, not so exceedingly rare as might be imagined, and probably a good deal of the unsatisfactory behavior of some concrete foundations may be traced to a similar cause, perhaps not to open dishonesty as in the example mentioned, but to ignorance.

Heavy anvil blocks interposed between the mortar and the concrete foundation are unnecessary and objectionable. It is sufficient if the mortar be provided with a rather wide base, and that the underside be machined off carefully, so as to be absolutely straight and have an even bearing on the concrete foundation.

As far as the batteries themselves are concerned, modern tendencies seem to lean towards an increased weight of the stamps, except, of course, in such cases where the character of the ore is such that it slimes easily, and an excessive sliming is objectionable. Stamps of 1,350 pounds weight are by no means a rarity, and good results have even been reported from South Africa with still heavier stamps, of 1,450 pounds weight

This practice is in line with the general increasing tendency to regard the stamps simply as one link in the cycle of crushing machinery, to be used for what might be called preliminary crushing, especially when they are supplemented by tube mills. In such cases the aim is, of course, directed towards putting through the batteries as large a quantity of material as possible, and to increase the aperture of the battery screen We thus hear from South Africa of such stamp duties as 7.8 tons per stamp per day, in the Knights Deep Mill, the latter figure having been obtained with 1,450-pound stamps.

One feature of a modern mill, and which is much to be recommended, is the adoption of suspended ore feeders to the batteries, with the attendant advantage of every accessibility of the feeders as well as the stamp batteries for the purpose of inspection and repair. The unobstructed floor space thus gained behind the batteries is of great assistance in facilitating the supervision of the machinery and providing the necessary accessibility to the parts.

Automatic ore feeders have come to be recognized as such essential auxiliaries in stamp mill sthat there is no need on dwelling upon them at this place. There are a number of types in use, and others are still being introduced, the aim of the constructors being to improve and facilitate the operation of the feeding devices and to provide for the possibility of easy regulation.

It was also clearly evident that a great deal of attention was paid to the fine grinding of materials and the regrinding of the tailings. For this purpose the tube mill has now established a well-defined place for itself in metallurgy, and continues to make its way. As far as the tube mills are concerned, it is not to be denied that they are certainly very effective instruments for fine grinding.

There are already a good many data relating to the subject of tube milling, but as yet no method has been elaborated by which the work done by the various tube mills can be strictly compared. The common method at present in use simply relies upon the diminution of a certain size, usually the product which passses through a 60-mesh sieve, and the difference between the percentage remaining on the sieve before and after the passage of the material through the tube mill is taken to indicate the amount of crushing work performed by the mill.

This method is not altogether satisfactory, inasmuch as it does not take account of the difference in the battery screens, the pulp of which feeds the mills, and, therefore, results obtained at different plants are not strictly comparable. It has lately been proposed to calculate the relative surface area of the particles of crushed material before and after its passage through the tube mill, and thus to ascertain the efficiency of the crushing work done by the latter Some such method will have to be adopted in order to be able to strictly compare results.

The introduction of the tube mill has been very rapid, especially in Western Australia and in the Transvaal, and the mills have given upon the whole very good satisfaction. It seems to have been clearly established that short mills are more effective than longer ones, and it is stated that, for instance, in Australia, the majority of the mills are 13 feet long, and have been found to do more effective work per horse-power than the others. This experience has also been confirmed at the El Oro (Mexico) plant.

As far as the lining of the tube mills is concerned, it appears that silex is at the present time the material which is mostly in use, with the possible exception of Australia. The silex lining has shown itself to be much preferable to the chilled iron or manganese steel linings, especially in those cases where the material going into the tube mill is ground fine in one passage through the mill.

On the other hand, in Australia, chilled iron liners are given the preference, but in those mills the material is constantly returned to the mill until it passes 150-mesh screen, so that the material with which the mill deals is in a much finer state of division from the start.

In the United States, silex liners are employed in the majority of cases, and it has been found that a better wear is obtained by putting the bricks which compose the lining on edge instead of laying them flat. The bricks generally are 2½ inches thick, 4 inches wide and 8 inches long

The subject of tube milling is gradually beginning to be understood, and the best conditions for the cheapest and most effective operation are being ascertained It has been found among other things that a great deal depends upon the previous classification of the material that is to be ground in the mill.

In the beginning, the lining as well as the pebbles were subjected to a great deal of wear and tear, by reason that the mill was fed with pulp of too thin a consistency, or did not receive enough of the material It has been ascertained that the tube mill will do its best work when it receives the pulp in a rather thick condition, say about 50 per cent of moisture, and that under these conditions the output will be a maximum and the wear and tear of liners and pebbles a minimum.

In order to get this favorable consistency of the pulp it becomes necessary to introduce a classifier into which the pulp

into the mill. It has now become recognized that such a classifier is a very important auxiliary, and that a sufficient amount of surface should be allowed so that the settling of the pulp can proceed properly.

Two more tube mill plants accordingly have classifiers of proper size. Each thus gain the two-fold advantage of a maximum production and minimum wear of liners and pebbles as well as relieving the mills from a great amount of material which is already fine enough and therefore need not be passed through the mill.

The question of the liners, as mentioned above, is being solved in different fashion in the various countries where tube mills have been introduced, in accordance with the character of the ore. A notable advance in the construction of the lining has been made by Mr P. Berry, the chief engineer of the Waihi Gold Mining Co., of New Zealand.

Mr Berry intends to facilitate the laying and the repair of the tube mill lining, and for this purpose he constructs the lining of a series of rectangular hollow cast-iron segments, so that it presents a sort of honeycombed appearance. The segments are curved to conform to the shape of the mill. Pieces of silex are cemented into the individual segments.

It is reported that this construction has worked with great satisfaction at the Waihi mine. The construction is particularly adapted to a quick repair of the lining when the latter, as happens quite frequently, is worn out in places. It is then only necessary to replace the worn-out segment or segments by new ones, and the mill is ready to start again in short order.

The time required for the repair of the lining, which very frequently is a serious and costly item, has been decreased materially at the Waihi plant by the installation of this lining. The reduction in cost is given as about $1,000 per mill per annum.

The old controversy between the tube mills and pans is by no means settled, and probably will not be for some time to come. It is, however, becoming customary to pass the product issuing from the tube mills again over a series of amalgamating plates, in order to catch any free gold which may have become liberated in the mill.

Such is, for instance, the practice at the Liberty Bell Mill, Telluride, Col., lately visited by the writer, where three Abbé tube mills are working, two being in operation and one in reserve. The mill has a total capacity of 80 stamps, crushing through a 14-mesh screen. The stamps weigh 850 pounds and drop 100 times per minute 6 inches high. The stamp duty is given at 4.3 tons per 24 hours. The pulp passes over the plates, and after flowing into a Dorr classifier it is delivered to the tube mills in a thickened condition. One of these classifiers handles the product of 40 stamps.

The Dorr classifier at this plant is stated to have given good service, although its settling capacity is somewhat too small in this particular instance. The classifier is a comparatively simple apparatus, inasmuch as it consists essentially of a longitudinal trough with inclined sides, which is fitted with a sort of mechanical scraper. This scraper is constructed with a series of rakes, and works in such a manner that it constantly scrapes up the heavy material which has settled in the bottom of the tank and moves it over the inclined bottom until it reaches the feed arrangement of the mill.

The latter are 22 feet long and 5 feet wide, and are supported by means of two tires, one near each end, upon four small wheels or friction rollers. The tube mills are lined with flint bricks 4 inches thick set on edge, and are run at about 25 r. p. m.

The spiral feed of the Abbé type of mill is stated to have been very satisfactory. The tube mills grind about 95 tons each per 24 hours, and about 85 to 90 per cent of the material which they discharge will pass through a 100-mesh screen.

The pebbles used in the mill are the regular imported product, of an average size of 2½ inches, and their consumption is given as 1.3 pounds per ton of ore ground.

The mill carries a load of pebbles of about 14 tons, being two-thirds filled. The product discharged from the mill has the following fineness: On 40-mesh, 40 per cent; on 80-mesh, 13 per cent; on 100-mesh, 15 per cent; on 200-mesh, 23 per cent; through 200-mesh, 48 per cent.

The pulp issuing from the mills, as mentioned above, passes again over a system of amalgamating tables, six plates being provided for each mill. From there it goes to five large settling tanks, 30 feet x 10 feet, preparatory to being charged into the agitating vats for cyaniding. It is an interesting fact that the whole crushing process at the Liberty Bell mill takes place in cyanide solution, but the latter is comparatively weak, as it only stands in the battery mortars at about 1 pound of cyanide per ton. It is strengthened up in the agitators to 1¾ pounds of cyanide per ton.

The question of crushing with or without cyanide solution has been discussed for some time, and it is generally conceded that under ordinary circumstances the practice is not to be recommended. On the whole, it is not so much a metallurgical as a commercial question.

If the attack of the cyanide solution on the plates and the deterioration of the latter is sufficiently high in cost to counterbalance the amount of gold saved, or the greater percentage extracted in cyaniding, it is obviously a better policy to discard crushing in cyanide solution. At the Liberty Bell it has been decided that the advantages gained are sufficient to continue its use, especially in view of the use of the tube mills, which aid very effectively in the extraction of the values, besides serving as grinding machines.

In contradistinction to that, at both mills of the Smuggler Union Gold Mining Co., which are located only a short distance from the Liberty Bell, and work on a similar ore, the practice of crushing in cyanide solution has not been adopted. At this place the tube mills are not utilized in the ore treatment.

The tube mill has also, but comparatively recently, been introduced as an apparatus for the regrinding of tailings, with a view to obtain a closer saving of the values. When it is used in such a capacity the object is, of course, not fine grinding preliminary to subsequent cyanidation, but simply a regrinding of the tailings obtained from the treatment of the battery pulp on the first set of coarse tables.

The tube mill in that case acts simply as an auxiliary to the stamps, and serves in the same capacity as the Huntingdon or Bryan mill or similar apparatus, which are used for the same purpose. When it is employed in such a manner, the object may simply be to obtain an improved recovery by the regrinding of the tailings, which are then subsequently treated on concentrating tables and their values recovered. Thus the values contained in the tailings and which in the older types of mill were allowed to go to waste are saved.

In such cases the battery screen may not be changed, and the mills are not used for what might be called very fine grinding or sliming, but simply for comminuting the ore sufficiently to recover the metallic contents. In cases where the gold values in the ore warrant it, auxiliary amalgamating tables may also be introduced between the tube mills and the concentrating tables, in order to save the additional amount of free gold liberated in the crushing operation in the mill.

In other cases an object in installing the tube mill may be the increase of the capacity of the plant by the use of a coarser screen in the batteries, and the utilization of the tube mill as an auxiliary crushing machine, for recrushing the coarse tailings obtained after the first coarse concentration. Whether the tube mill is the most economical instrument to be used in such cases as mentioned above, does not seem to be altogether certain. In any case final judgment cannot be pronounced until the mills have been in operation for some time and comparative data are available.

The initial cost of the tube mills is, of course, quite an item, and the necessity of keeping a spare unit of rather large dimen-

sions is not to be disregarded. Still, the plants who have adopted them for auxiliary crushing seem to be satisfied with the results, and at least one large company has recently installed a new plant for the treatment of ore similar to that dealt with in its first plant, and has adopted tube mills in the second plant also. In view of these facts the future of the tube mill as an essential adjunct in modern metallurgical practice seems assured.

The cost of silex linings for tube mills is quoted as $0.6 to 1.00, according to quality, per square foot of lining area, when the bricks are laid flat, so that the lining has a thickness of 2½ inches. When the bricks are set on edge, making the thickness of the lining 4 inches, the cost increases to about $0.9 to 1.60 per square foot of lining area. These prices apply to the material f. o. b. New York. A lining of 4-inch thickness might reasonably be expected under average conditions to last about eight to ten months, and probably will last much longer, judging from experience obtained in South Africa. The cost of pebbles f. o. b. New York is about $11.00 to $16.00 per ton, and their consumption may be calculated on an average as about 2 pounds of pebbles per ton of ore crushed. It will vary of course with the character of the ore and the fineness of the product required. As far as the cost of tube milling is concerned, a large representative machinery house, which has had much experience in the installation of tube mills, quotes the following figures as representing the practice at a representative tube mill plant: Power, 3.6c.; wages, 2.82c.; liners, 2.0c.; maintenance (including tables), 1.36c.; pebbles, 1.16c.; sundry stores, 0.48c.; a total of 11.42c. per ton. The costs at the Robinson Deep Gold Mining Co., on the Witwatersrand, are given by Mr. W. R. Dowling, the manager of the plant, in the journal of the Chemical, Metallurgical and Mining Society of South Africa, 1906, p. 308, as follows, for a total of 29,235 tons: Maintenance, 0.72c.; wages, 2.86c.; power, 3.78c.; sundry stores, 0.52c.; pebbles, 1.4c.; liners, 1.86c., or a total of 11.14c, which figure shows a remarkably close correspondence to the first quoted one.

The cost of tube milling at the Combination mill, Goldfield, Nev., with over 40 cents per ton of ore stamped represents about the maximum, on account of the high cost of labor and freight. Mr. F. L. Bosqui, in a paper read at the recent Denver meeting of the American Mining Congress, gave the following data about this plant: Cost of 2½ inches silex lining, laid in mill, $323.50; life of lining, four months; cost of lining, 7.7 cents per ton of ore stamped; cost of pebbles delivered at Goldfield, Nev., $71 per ton; consumption of pebbles, 2.03 pounds per ton of ore stamped; cost of pebbles, 7.1 cents per ton of ore stamped; horse-power, 25 hp. at $4.25 per hp. per month, cost 26.7 cents per ton of ore stamped. The total cost is, therefore: Pebbles, $.071; lining, $.077; power, $.267 = $.415. The tube mill in this case is 12 x 4 feet, and handles about 24.6 tons per day, sliming the product of a Bryan mill with a 40-mesh screen.

In close connection with the increased use of tube mills for fine grinding stands the progress made in cyanidation, and especially the processes intended to facilitate the treatment of the slimes. The efforts seem to be mainly directed towards cheapening the slimes treatment. In these days of comparatively low-grade ores the reduction of costs is a very important consideration, in fact, for many ores a *conditio sine qua non*. It is sufficiently evident that the treatment of the slimes in filter presses is a very laborious and costly operation on account of the skilled labor required and the comparatively small capacity of a press. On the other hand, the decantation method of slimes treatment involves a great bulk of solution and the installation and up-keep of quite a number of tanks, and on that account it has not been regarded with a great deal of favor. The main object of the new methods of slime treatment has, therefore, been to lower the cost of filter-pressing by providing filtering units of cheap construction and very large filtering area, and to facilitate the discharge of the resulting cake of slime by adopting mechanical means for its removal.

One of the processes based upon these ideas and which has been installed at several places is the Moore filtering process. The process depends essentially on filtering the slimes pulp by the aid of a vacuum, the residual cakes of slime adhering to the canvas filter frames of special construction. When the cakes have reached a sufficient thickness, the whole filter set, comprising a series of frames, is raised from the filtering tank and introduced into a wash-water tank, where the application of the vacuum is continued until the strength of the solution has fallen down to the required amount.

When the washing has been completed, the filter set is raised again and run over a discharge hopper, the vacuum still being maintained until the excess of moisture is removed. After that air pressure is turned into the filter frames, and the cakes are gradually loosened until they drop off. This was essentially the practice at the first installation at the Standard Mill at Bodie, Cal., where the filtering arrangement consists of forty-nine filter frames, 10 feet long and 5 feet wide; one set of filters had a total filtering area of 7,840 square feet. The results at Bodie, according to R. Gilman Brown (*Min. and Scient. Press*, Vol. 93, p. 192), have been very satisfactory, and have resulted in a saving of about $2.00 per ton. The costs are given as follows: General expenses, including superintendence, watchman, assays, insurance, taxes, chemicals, supplies, etc., $1.202; regrinding, $0.572; Moore process, $0.314; zinc room, $0.261; a total in the slimes plant of $2.349. This cost is expected to be brought down to well below $2.00.

The process has also recently been installed at the Liberty Bell Mill, at Telluride, Col., mentioned above, and is in active operation. As the practice at the Liberty Bell is based upon modern metallurgical ideas, a brief description will prove of interest. The tube mill practice at the plant has been mentioned above. The pulp discharged from the tube mill, after passing over the secondary amalgamating plates, is conducted to five large settling vats, passing through spitzlutten on the way, where the coarse product is caught and returned to the tube mills. The settling vats are 33 feet in diameter and about 10 feet deep.

The pulp is allowed to settle for 12 hours, after which about 5 feet of the clear solution are decanted off and pass directly to the strong zinc boxes. By means of central discharge valves the pulp is then conducted to six agitating vats of the Hendryx type. They are provided with a central tube, which contains a spiral screw; the latter scoops up the pulp from the bottom and delivers it at the top of the vat, thus giving it a thorough mixing and agitation. The agitator vats are 17 feet in diameter, and they have a cone-shaped bottom, their depth being 11 feet to the top of the cone. The capacity of the vats is 35 tons of dry ore per charge. In these agitators the cyanide solution is strengthened up to 1.2 pounds of cyanide per ton, and the pulp is agitated for about 12 hours, after which it is discharged into a storage tank by means of a centrifugal pump. Lead acetate is added to the solution in the agitating vats, and it is stated that the adoption of this practice has led to very beneficial results in the extraction, especially of the silver values. The main object in adding lead acetate is the removal of any soluble salts of lead and mercury in the form of insoluble lead and mercury sulphide, so that they cannot retard the solution of the gold and silver or reprecipitate any silver already dissolved.

From the storage vat the pulp goes to the Moore filtering plant, which is provided with six tanks, two of which are used for carrying on the filtering operation and the remaining four for the displacement of the filter cakes. The practice in the Moore plant differs in several respects from that adopted at Bodie, Cal. The assistant general manager of the Liberty Bell, Mr. E. H. Nutter, has had much practical experience in the practice of the Moore process, having been connected previously with the management of the Bodie plant.

As stated above, the length of the filters at the Bodie mill is 16 feet. This has been cut down to half of that length at the

Liberty Bell plant, and the number of filters in a set has been increased so that the filter unit now comprises sixty-six frames, covered with canvas duck, each frame being 8 feet long and 5 feet wide. A filter unit, therefore, has a total filtering area of nearly 6,400 square feet. This shorter length of the filter facilitates the handling considerably.

The filtering set is introduced into one of the filtering tanks and the solution is drawn through the filter, agitation being kept up meanwhile to prevent the pulp from settling. According to Mr. W. E. Tracy, the superintendent of the mill, in *Eng. and Min. Journ.* Vol. 82, p. 149, the filter sets remain in the tank for 1 hour, and during this time about 16 tons of solution are drawn through and a cake of 7/8 inch thickness is formed. The vacuum used is about 17 to 19 inches.

After this operation the basket is transferred by means of an hydraulic crane operated by an electric motor to a displacing tank, the gold-bearing cyanide solution is then displaced by water, but no intermediate weak cyanide solution is used. The cakes of slime, after they leave the filtering tank are stated to contain about 33 per cent of moisture, 75 per cent of which is drawn off in from 30 to 40 minutes, after the filter set has been transferred to the displacing tank. The strong solution from the Moore plant, together with the solution drawn from the settlers, is run to the ten strong zinc precipitation boxes, while the weak solution runs through the weak zinc boxes and then to waste. Before the strong solution goes to the boxes it passes a clarifying filter arrangement. The displacement is stated to be continued until the discharge from the vacuum pump shows .35 pound of cyanide per ton, and at that point there are left about 5c. to 7c. of dissolved values per ton of dry slime and about 3c. of cyanide.

A further important modification from the original practice at Bodie has also been introduced, namely, the cakes are not blown off from the filter frames by means of compressed air, but by water at 10 pounds pressure under water in the displacing tank. This procedure would seem to present decided advantages, inasmuch as the strain caused by the action of the air on the filters must be quite considerable and conducive to leaks, and leaky filter frames in such a process are a source of considerable trouble. The process as carried out at the Liberty Bell mill is stated to work satisfactory.

The total time required for one cycle of operations is about 2¼ hours, comprising 1 hour for filtering, 10 minutes for transfer of the set of filters to the unloading tank and about 1 hour and 35 minutes for washing the cakes, discharging the residue and transfering the filter unit back again to the filtering tank.

A second process, which aims at reducing the cost of the filtering operation is the Cassel Butters process, installed at the mill of the Combination Mine, Goldfields, Nev. It differs essentially from the Moore process by the fact that the filtering and removal of the filtered cakes take place in the same tank, the necessity for handling the filters being thus done away with. It is claimed that this arrangement leads to increased facility of operation and economy in labor. As installed at the small mill of the Combination Mine, the filtering apparatus, according to Mr. F. L. Bosqui (*Min. and Scient. Press*, Vol. 93, No. 16), consists of twenty-eight 5 x 10-foot frames, set 4½ inches apart in a box 10 feet square with a pointed bottom, which is inclined at an angle of 50°.

The slime pulp having been introduced at the point of the bottom, filtering is continued for about 20 minutes with a vacuum of 22 inches and a cake of ¾ to 1 inch thickness obtained on both sides of a frame. The pulp is then drawn off into a reservoir, and a weak cyanide solution is introduced, which serves as a wash. After the cakes are thoroughly washed this solution is drawn off into a special vat and the box is then filled with water, after which water, under pressure, is admitted to the interior of the filter frames and the cake of slime thus forced off the frames. The slime drops into the pointed bottom of the box and is removed by sluicing it out. The whole operation is stated to require 3½ hours, 9 tons of dry slime being treated at each charge by one man. The cost of filtering has decreased to 26c. per ton, as against 96c. with an old type of filter presses.

As stated above, filter pressing in the usual types of filter presses is quite a costly operation. Mr. C. W. Merrill, however, the well-known manager of the Homestake plant, has devised a new type of press, the principal points of interest about which are its large size and the fact that the filter cakes can be discharged by sluicing without opening the press. A press of this construction, 45 feet long, has a capacity of 20 tons, and is provided with ninety-two filter frames, 4 x 6 feet. The filtered cakes are 4 inches thick. A large plant is now in course of erection, and it is expected to treat slimes of an average value of less than $1.00 for about 25 cents. A notable departure from the usual practice is also the precipitation, at the Homestake mill, of the gold-bearing cyanide solution with zinc dust instead of zinc shavings.

In line with the above mentioned advances in the cyanide process is the installation, on a large scale, in a 100-stamp mill, of the Garvin electrocyanide process. This process, as described in Electrochemical and Metallurgical Industry, Vol. 4, p. 247, is based upon the thorough agitation of the pulp to be cyanided in a very weak solution of cyanide, the operation being supplemented by the electrolysis of the gold-bearing cyanide solution. In the plant under consideration, which is now being completed at Palmer Mountain, Wash., twenty Garvin apparatus will be installed, namely, one for each five stamps. The latter have a weight of 1,050 pounds, and drop 6 inches 105 times per minute. The battery screen is 40-mesh. As the ore is not a very hard one to crush a stamp duty of about 4 tons is expected. The Garvin apparatus has a capacity of 10 tons each.

In order to catch the coarse gold which might escape solution in the agitator tank, the pulp from the batteries is first delivered to a series of step amalgamating plates, four plates being provided for each agitator. This auxiliary apparatus is located on the top of the agitator tanks. These amalgamating plates are also kept under the influence of an electric current, which, however, performs no electrolytic function, the object being merely to keep a small current passing through the plates. It is claimed to have been demonstrated by practical experience that this method of procedure keeps the plates soft and prevents them from crystallizing.

The main agitation takes place in a very weak cyanide solution, namely, ¼ pound of cyanide per ton, and it is claimed that on this account it is possible to dissolve the precious metal values without experiencing any detrimental effects from the presence, for instance, of small amounts of copper. It will be very interesting to ascertain the results obtained by this installation when working on such a large scale, although it is claimed that tanks of the same size as those adopted in this plant have been successfully worked on a practical scale, and that the problems that are likely to arise have already been anticipated and solved.

Mineral Production of United States by States.—A new feature of the 1905 volume "Mineral Resources of the United States" of the United States Geological Survey is a series of tables, showing the value by States of the mineral products of the country. These include both certain raw materials and also products, for example, both iron ores and pig iron, both pig lead and lead paints, etc., regardless of the consequent duplication of values. Some of the results of these tables are quite surprising. For example, we think of Colorado and California as our most representative mineral States, and yet the actual value of Illinois mineral products ($105,065,567) was far greater than that of either Colorado ($50,280,944) or California ($43,406,258) last year. The list is headed by Pennsylvania ($569,828,673) and Ohio ($169,203,710). Illinois is third.

Water Gas.

(Translated from Baron Hanns Jüptner von Jonstorff's Chemical Technology of Energies.)

BY OSKAR NAGEL, PH. D.

Instead of producing fuel gases by the action of the oxygen in the air on glowing coal, we can use for this purpose the oxygen of water in place of the oxygen in the air.

If steam is led over glowing coal, according to the temperature, two different reactions will take place. At very high temperatures the reaction takes place according to the equation:

$$C + H_2O = CO + H_2$$

while with decreasing temperature a second reaction becomes more and more prevalent according to equation:

$$C + 2H_2O = CO_2 + 2H_2$$

The first equation is furnishing a mixture of equal volumes of CO and H_2: CO 50 per cent by volume and H_2 50 per cent by volume, while the second reaction, if taking place exclusively, furnishes a gas containing two volumes H_2 for every one volume of CO_2, hence CO_2 33.33 per cent by volume and H_2 66.67 per cent by volume. The thermal value of the first gas per 22.42 liters is 68 Cal., of the second gas 45.4 Cal.

A comparison of the generator (air) gas process with the two water gas processes shows:

	H_2	CO
(1) $C+\frac{1}{2}(O_2)+2N_2=CO+2N$	...	$33\frac{1}{3}$
(2) $C+2H_2O=CO_2+2H_2$	$66\frac{2}{3}$	...
(3) $C+H_2O=CO+H_2$	50	50

The figures of thermal value refer to the same gas volume in each case, and are well adapted for comparing the qualties of the gases. In case, however, we want to consider the utilization of fuel, we have to refer the thermal values to equal quanties of carbon (equal volumes of CO and CO_2), and we obtain

	12 Grams C. Yield Liters of Gas.	Value of the Gas at Constant. Volume.	Pressure.
(1)	67.26	67.8 Cal.	68.7 Cal.
(2)	67.26	136.2 Cal.	130.5 Cal.
(3)	44.84	136.0 Cal.	137.0 Cal.

We see that water gas even under the most unfavorable circumstances yields more heat (thermal value) than the ideal air (generator) gas, besides the fact that it contains less non-combustible gases.

For making a perfect comparison we have to calculate at least—if not the pyrometric heating effect—the quantity of air theoretically required for combustion. We have for each 22.42 liters of gas:

	Composition of Gas in % by Volume.				Theoretical Amount of Air.		Combustible	Indifferent Gases.	Products of Combustion.		
	H_2	CO	CO_2	N_2	O_2	N_2			H_2O	CO_2	N_2
(1)	...	$33\frac{1}{3}$	...	$66\frac{2}{3}$	$16\frac{2}{3}$	$64\frac{2}{3}$	$33\frac{1}{3}$	$131\frac{1}{3}$	...	$33\frac{1}{3}$	$66\frac{2}{3}$
(2)	$66\frac{2}{3}$	...	$33\frac{1}{3}$	...	$33\frac{1}{3}$	$133\frac{1}{3}$	$66\frac{2}{3}$	$166\frac{2}{3}$	$66\frac{2}{3}$	$33\frac{1}{3}$	$133\frac{1}{3}$
(3)	50	50	...	...	50	200	100	200	50	50	200

As the decomposition of water requires more heat than is furnished by the formation of CO, and even CO_2, both water gas processes are taking place only with the assistance of external heat. We have:

$C+\frac{1}{2}(O_2)=CO+21100$ Cal.

$C+2H_2O=CO_2+2H_2+97600-138000=CO_2+2H_2-40.4$ Cal.

$C+H_2O=CO+H_2+26100-69000=CO+H_2-42.9$ Cal

Considering the external heat we have.

	Thermal Value of Gas per 12 Grams C.	External Heat to be Supplied	Gain in Heat.
$C+\frac{1}{2}(O_2)+2N_2=CO+N_2$	68.7 Cal.	−21.1 Cal	89.8
$C+2H_2O=CO_2+2H_2$	130.5 Cal.	+40.4 Cal.	90.1
$C+H_2O=CO+H_2$	137.0 Cal.	+42.9 Cal	94.4

The absolute gain in heat is therefore not very great in water gas, and becomes less if we take into consideration losses of heat, which we cannot avoid, when furnishing the external heat to the producer. The advantage of water gas, therefore, does not consist in a gain in heat, but exclusively in the higher thermal value of this gas, which allows a better utilization in the combustion.

As can be seen from the above statements, the reaction $C + H_2O = CO + H_2$ will take place if steam is led through a layer of sufficiently hot coal. As heat is absorbed by this reaction, the coal will cool off, and besides the above reaction, the process $C + 2H_2O = CO_2 + 2H_2$ will take place. As the cooling continues the second process will begin to outweigh the first, and finally, since the second reaction also absorbs heat, the coal will be so cold that the reaction will stop, and thus the steam will go through the fuel undecomposed.

This necessitates reheating the coal in the generator. This is done by shutting off the steam and blowing air through the generator until the coal is sufficiently hot. During this period air (generator) gas is produced which can be utilized independent of the water gas. This period is called "hot-blowing." As soon as the coal is hot again, the air blast is stopped and the steam valve opened, and water gas is made until the cooling off of the fire prevents the rational production of water gas.

Vol. %		Thermal Value of 1 Volume Cal.	Of Mixture at Constant Pressure Cal.
CO_2	N_2		
...	$66\frac{2}{3}$	22.6	22.9
$33\frac{1}{3}$	...	45.4	46.5
...	...	68.0	68.5

We, therefore, have here an intermittent process, which not only requires careful supervision but also the erection of double the number of generators in places where a continuous stream of water gas is required, and where a large gas holder is objectionable.

As we have seen, the two water gas reactions are taking place in parallel. Since, however, the one furnishes a superior gas with better utilization of coal than the other, it is of importance to know the conditions which determine to which extent each of the two reactions will take place. For this purpose we have to study the state of equilibrium between the two reactions.

To find the equilibrium of the gas phase, we have to consider the reactions that are taking place. If we deduct

$C + H_2O = CO + H_2$ from

$C + 2H_2O = CO_2 + 2H_2$ we get

$CO_2 - H_2 \rightleftarrows CO + H_2O$

This is a reversible reaction in which two volumes ($CO + H_2O$) are formed from two volumes ($CO_2 + H_2$). It is, therefore, independent of pressure at all temperatures above the boiling point of water. One might now conclude that the composition of water gas at a given temperature is independent of the pressure; this, however, is not correct. From the last equation we get for the isothermic equilibrium

$$K = \frac{C_{CO_2} \cdot C_{H_2O}}{C_{CO} \cdot C_{H_2}} \quad \text{or} \quad \frac{C_{CO}}{C_{CO_2}} \cdot \frac{C_{H_2}}{C_{H_2O}} = K$$

We, therefore, see that at a given temperature there is corresponding to every $\frac{CO}{CO_2}$ a different $\frac{H_2}{H_2O}$. To reach definite results we have to look for a reaction which determines the equilibrium between the gas phase (in our case consisting of

... CO, H and H_2O and the solid phase (C), and as such we are going to use the calculation mentioned already in the case of gas reactions.

$CO_2 + C = 2CO$ from this equation we have

$K = \frac{[CO]^2}{[CO_2]}$

...

And now the conditions are given for calculating the isothermic equilibrium. As the last mentioned reaction depends on the pressure, we must necessarily conclude that the composition of water gas also depends on the pressure.

We are going to discuss now the theory of the water gas process in a few words. If we express the steam pressure by P and the gasifying temperature (in ° C.) with t, the ideal composition of the water gas (i. e. the composition corresponding to the equilibrium reached) is as follows:

Quantity of combustible gases present in ideal water gas:

Steam Pressure in Atm.	*Gasifying Temperature in ° C.*					
	400	600	800	1000	1200	1400
0.1	22.23	79.00	99.07	100.00	100.00	100.00
0.25	15.96	69.76	97.88	100.00	100.00	100.00
0.5	12.05	63.60	96.12	100.00	100.00	100.00
0.75	10.16	58.70	94.52	100.00	100.00	100.00
1.0	8.97	55.78	93.08	100.00	100.00	100.00
1.5	7.50	51.62	90.44	99.34	100.00	100.00
2.0	6.58	48.80	88.24	99.34	100.00	100.00
2.5	5.95	46.64	86.34	98.90	100.00	100.00
3.0	5.48	44.90	84.62	98.36	100.00	100.00
4.0	4.83	42.20	81.66	98.12	99.14	100.00
5.0	4.32	40.21	79.14	97.70	99.11	100.00
10.0	3.11	34.38	70.86	95.66	99.11	100.00

As one Mol of every gas at 0° and 760 mm. pressure occupies a space of 22.42 liters, we can calculate the thermal value of

	Steam Pressure, P, in Atmospheres.											
	0.1	0.25	0.5	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	10.0
t = 400° C.												
CO	0.24	0.12	0.06	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.00
CO_2	10.88	7.86	5.97	5.04	4.46	3.73	3.27	2.97	2.73	2.40	2.15	1.55
H_2	21.99	15.84	11.99	10.12	8.94	7.48	6.56	5.94	5.47	4.82	4.31	3.11
H_2O	66.88	76.18	81.98	84.80	86.57	88.77	90.15	91.08	91.79	92.77	93.53	95.34
t = 600° C.												
CO	26.66	18.87	14.65	11.56	10.03	8.14	6.90	6.20	5.61	4.78	4.22	2.87
CO_2	12.84	16.06	17.15	17.79	17.86	17.07	17.41	17.12	16.84	16.32	15.88	14.32
H_2	52.34	50.89	48.95	47.14	45.75	43.48	41.81	40.44	39.29	37.42	35.99	31.51
H_2O	8.16	14.18	19.25	23.51	26.36	30.71	33.79	36.24	38.26	41.48	43.01	51.30
t = 800° C.												
CO	49.04	47.81	46.04	44.46	43.06	40.56	38.53	36.83	35.41	32.81	30.69	24.38
CO_2	0.50	1.13	2.02	2.80	3.48	4.66	5.59	6.34	6.95	8.02	8.88	11.05
H_2	50.03	50.07	50.08	50.06	50.02	49.88	49.71	49.51	49.21	48.85	48.45	46.48
H_2O	0.43	0.99	1.86	2.68	3.44	4.90	6.17	7.32	8.43	10.32	11.98	18.09
t = 1000° C.												
CO	50.00	50.00	50.00	50.00	50.00	49.42	49.42	49.00	48.57	48.35	47.98	46.24
CO_2	.....	.....	.....	.....	.....	0.25	0.25	0.45	0.61	0.71	0.87	1.59
H_2	50.00	50.00	50.00	50.00	50.00	49.92	49.92	49.90	49.79	49.77	49.72	49.42
H_2O	.....	.....	.....	.....	.....	0.41	0.41	0.65	1.03	1.17	1.43	2.75
t = 1200° C.												
CO	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	49.32	49.31	49.31
CO_2	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.25	0.25	0.25
H_2	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	49.82	49.80	49.80
H_2O	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.61	0.64	0.64
t = 1400° C.												
CO	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
CO_2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
H_2	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
H_2O	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Figs. 1 and 2 show the ideal composition of water gas at a steam pressure of one and four atmospheres. We see from the diagrams that with increasing pressure the curves are moving towards higher temperatures. We also see that the quantity of undecomposed steam present is rapidly decreasing from a certain temperature on, while the quantity of CO and H_2 is rapidly increasing in the same manner. The curves of CO and H_2 are in their middle part practically parallel, but the upward movement of the H-curve is beginning 200° C. below the bend of the CO curve.

The CO_2 curve starts to rise together with the H curve (but more slowly), until it crosses the steam curve and falls with the latter. The result of this discussion for the practice is, that the most favorable gasifying temperature is between temperature limits of about 200°, and increases with the steam pressure.

This becomes clearer when we calculate the quantity of combustible gases (CO and H_2) present in water gas (Fig. 3).

As the combustion of one Mol CO yields 68,600 Cal., the combustion of one Mol H_2 to liquid water 68,400 Cal., which is practically the same amount of heat, we can use the above table for comparing the thermal value of the different gases. 1 cubic meter of the above gases in large Calories by multiplying their content of combustible gases with

$$\frac{1000 \times 68.5}{100 \times 22.42} = 30.6$$

Thermal value of 1 cubic meter of ideal water gas in large Calories:

Steam Pressure in Atm.	*Gasifying Temperature in ° C.*					
	400	600	800	1000	1200	1400
0.1	680	2417	3032	3060	3060	3060
0.25	590	2135	2995	3060	3060	3060
0.5	369	1946	2941	3060	3060	3060
0.75	311	1715	2892	3060	3060	3060
1.0	274	1707	2848	3060	3060	3060
1.5	230	1580	2767	3040	3060	3060
2.0	201	1493	2700	3040	3060	3060
2.5	182	1427	2642	3026	3060	3060
3.0	168	1374	2589	3010	3060	3060
4.0	148	1353	2499	2002	3034	3060
5.0	132	1230	2422	2990	3033	3060
10.0	95	1052	2168	2927	3030	3060

This table shows more clearly that the thermal value of the ideal water gas increases with increasing temperature and decreases with increasing pressure.

At a steam pressure of 1 to 2 atmospheres the most favorable gasifying temperature is between 800° to 1,000° C., and at 10 atmospheres pressure between 1,000° and 1,300° C. It is, therefore, not advisable to use steam of too high pressure.

The quality of the water gas is deteriorated by its content of undecomposed steam and of CO_2. We, therefore, will consider the influence of pressure and temperature on the quantity of H_2O and CO_2 present in the gas.

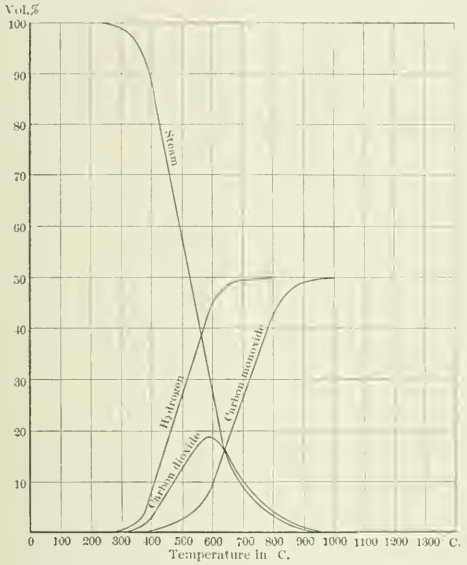


FIG. 1.—IDEAL COMPOSITION OF WATER GAS IN PER CENTS BY VOLUME AT 1 ATMOSPHERE PRESSURE.

The quantity of undecomposed steam in the ideal water gas decreases rapidly (Fig. 4) with increasing gasifying temperature and slowly increases with the pressure. As thereby the inflammability of the gas is decreased, the gasifying temperature should not be below 700° to 800° C. with a steam pressure of 1 to 10 atmospheres, since otherwise the quantity of undecomposed steam will be considerably above 10 per cent by volume.

The content of CO_2 (Fig. 5) is injurious, as it causes an unfavorable utilization of the carbon. Moreover, it deteriorates the gas, increasing the quantity of non-combustibles and lowering the temperature of combustion. As the CO_2 amounts only to a few per cents at 600° to 700° C., it has not to be considered in the production of generator gas.

In practice, however, it is of importance to know the quantities of carbon and steam which are required for the formation of 1 cubic meter of water gas. This information is given in the following tables:

Quantity of steam in m^3 required for the formation of 1 m^3 of ideal water gas:

Steam Pressure in Atm.	*Gasifying Temperature in ° C.* 400	600	800	1000	1200	1400
0.1	0.8887	0.6050	0.5046	0.5000	0.5000	0.5000
0.25	0.9202	0.6057	0.5106	0.5000	0.5000	0.5000
0.5	0.9397	0.6820	0.5194	0.5000	0.5000	0.5000
0.75	0.9492	0.7065	0.5274	0.5000	0.5000	0.5000
1.0	0.9551	0.7211	0.5346	0.5000	0.5000	0.5000
1.5	0.9625	0.7419	0.5478	0.5033	0.5000	0.5000
2.0	0.9671	0.7560	0.5588	0.5033	0.5000	0.5000
2.5	0.9702	0.7668	0.5683	0.5505	0.5000	0.5000
3.0	0.9726	0.7755	0.5764	0.5092	0.5000	0.5000
4.0	0.9759	0.7890	0.5917	0.5094	0.5043	0.5000
5.0	0.9784	0.7990	0.6043	0.5115	0.5044	0.5000
10.0	0.9845	0.8280	0.6457	0.5217	0.5041	0.5000

Therefore 1 cubic meter of steam furnishes the following numbers of cubic meters of ideal gas:

Steam Pressure in Atm.	*Gasifying Temperature in ° C.* 400	600	800	1000	1200	1400
0.1	1.125	1.653	1.981	2.000	2.000	2.000
0.25	1.087	1.537	1.958	2.000	2.000	2.000
0.5	1.068	1.466	1.925	2.000	2.000	2.000
0.75	1.053	1.415	1.896	2.000	2.000	2.000
1.0	1.047	1.386	1.871	2.000	2.000	2.000
1.5	1.039	1.348	1.825	1.986	2.000	2.000
2.0	1.034	1.323	1.789	1.986	2.000	2.000
2.5	1.031	1.304	1.759	1.978	2.000	2.000
3.0	1.028	1.289	1.735	1.963	2.000	2.000
4.0	1.024	1.269	1.690	1.963	1.983	2.000
5.0	1.022	1.251	1.655	1.955	1.982	2.000
10.0	1.015	1.208	1.548	1.916	1.982	2.000

The last table is specially valuable for this practice, since it permits an easy control of the operation of the generator and allows the determination of the ideal gasifying temperature, which corresponds to the process. The content of one component of the gas, for instance CO_2 (which can be easily determined with an Ados or Strache apparatus) being known, the complete analysis of the gas can be found.

One cubic meter of water gas contains grams of C.:

Steam Pressure in Atm.	*Gasifying Temperature in ° C.* 400	600	800	1000	1200	1400
0.1	59.51	211.40	265.14	267.60	267.60	267.60
0.25	42.71	186.95	261.23	267.60	267.60	267.60
0.5	32.27	170.19	257.22	267.60	267.60	267.60
0.75	27.19	157.08	252.94	267.60	267.60	267.60
1.0	24.03	149.27	249.08	267.60	267.60	267.60
1.5	20.07	138.14	242.07	265.83	267.60	267.60
2.0	17.61	130.59	236.13	268.83	267.60	267.60
2.5	17.05	124.81	231.05	264.66	267.60	267.60
3.0	14.66	120.15	226.71	263.21	267.60	267.60
4.0	12.90	112.93	218.52	262.57	265.30	267.60
5.0	11.56	107.58	211.78	261.45	265.25	267.60
10.0	8.30	91.06	189.62	255.99	265.25	267.60

One cubic meter of steam gasifies grams of C. (Fig. 6):

Steam Pressure in Atm.	*Gasifying Temperature in ° C.* 400	600	800	1000	1200	14000
0.1	66.96	349.44	525.44	535.20	535.20	535.20
0.25	46.41	287.30	511.61	535.20	535.20	535.20
0.5	34.81	249.54	495.23	535.20	535.20	535.20
0.75	28.64	222.34	479.50	535.20	535.20	535.20
1.0	25.16	207.00	465.92	535.20	535.20	535.20
1.5	20.85	186.19	441.89	528.17	535.20	535.20
2.0	18.21	172.74	420.77	528.17	535.20	535.20
2.5	17.57	162.77	406.54	523.56	535.20	535.00
3.0	15.07	154.93	393.32	516.91	535.20	535.00
4.0	13.22	143.13	369.31	511.52	526.17	535.20
5.0	11.81	134.64	350.45	511.14	525.87	535.20
10.0	8.43	115.06	293.67	490.68	525.87	535.20

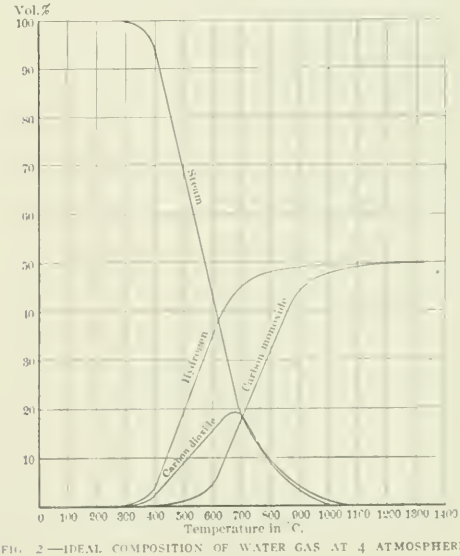


FIG. 2.—IDEAL COMPOSITION OF WATER GAS AT 4 ATMOSPHERES PRESSURE.

If the steam is blown through a layer of glowing coal the reaction will undoubtedly take place completely on the contact points of steam and coal, *i. e.*, the state of equilibrium will soon be reached here. On his further way the gas current will undergo a change in two respects. Partly by diffusion, partly by mechanical mixture, a reaction will take place between the outer part of the current and the inner part, which is richer in steam; on the other hand, the equilibrium of the outer layer will be disturbed by the contact of same with other parts of the coal.

If the gas passes from the cold to the hot coal layers ("Gegenstrom"), a gas rich in CO_2 will be formed at first in the outer layer; then, by coming in contact with hot coal, it is enabled to oxidize new quantities of coal, getting thereby richer in CO. If, however, the steam passes from the hot to the cold coal layers ("Parallelstrom"), a gas rich in CO will be formed at first in the outer layer, and by passing further it will get richer in CO_2 and poorer in CO.

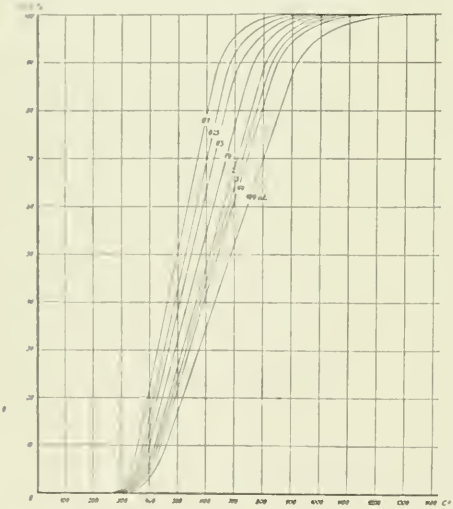


FIG. 3.—CONTENT OF COMBUSTIBLE GASES IN IDEAL WATER GAS.

constant pressure decreases with increasing temperature, while CO and H_2 increase simultaneously. On the other hand CO_2 increases at constant temperature with the pressure, while H_2 and CO decrease simultaneously.

The following table shows the cubic meters of dry gas produced from 1 cubic meter of steam:

Steam Pressure in Atm	*One M^3 of Steam is Yielding at the Temperatures Stated Below, M^3 Dry Water Gas.*					
	400°C.	600°C.	800°C.	1000°C.	1200°C.	1400°C.
1.	0.373	1.518	1.972	2.000	2.000	2.000
1.25	0.259	1.304	1.939	2.000	2.000	2.000
1.5	0.192	1.184	1.889	2.000	2.000	2.000
1.75	0.160	1.082	1.845	2.000	2.000	2.000
2.	0.141	1.021	1.807	2.000	2.000	2.000
2.5	0.117	0.934	1.736	1.978	2.000	2.000
3.	0.102	0.876	1.670	1.978	2.000	2.000
3.5	0.092	0.831	1.630	1.965	2.000	2.000
4.	0.084	0.796	1.589	1.943	2.000	2.000
4.5	0.074	0.743	1.516	1.940	1.971	2.000
5.	0.066	0.702	1.457	1.927	1.969	2.000
6.	0.047	0.588	1.268	1.863	1.960	2.000

The same conditions for producing the dry water gas are the same as for the wet gas. We have so far discussed the case in which the state of equilibrium is actually reached in the producer. We are now going to consider the case which is very common in practice, that the equilibrium is not reached.

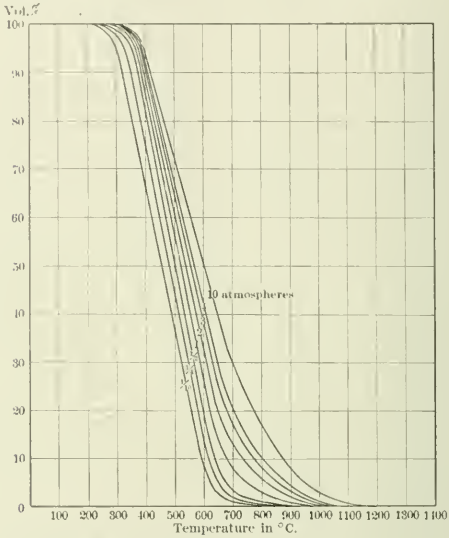


FIG. 4.—CONTENT OF UNDECOMPOSED STEAM IN IDEAL WATER GAS.

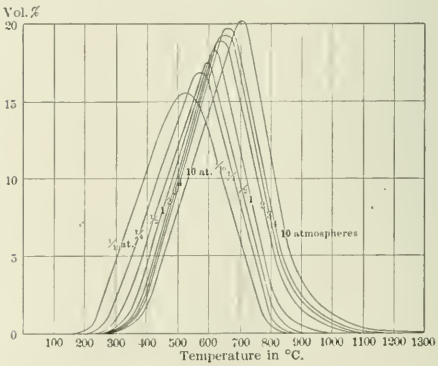


FIG. 5.—CONTENT OF CARBON DIOXIDE IN IDEAL WATER GAS.

1 Cubic Meter Dry Gas.	Pressure of the Rejected Steam in Atmospheres. 0.1	0.25	0.5	0.75	1.0	1.5	2.0	2.5	3.0	4.0	5.0	10.0
					$t = 400°$ C.							
Vol. % CO	0.72	0.50	0.30	0.20	0.20	0.18	0.18	0.15	0.14	0.12	0.11	....
" CO_2	32.85	33.00	33.13	33.16	33.20	33.21	33.21	33.23	33.24	33.25	33.26	33.33
" H_2	66.43	66.50	66.57	66.58	66.60	66.61	66.61	66.62	66.62	66.63	66.63	66.67
" Combustible gas	67.15	67.00	66.84	66.84	66.80	66.79	66.79	66.77	66.76	66.75	66.74	66.67
Thermal value	2054	2050	2046	2045	2044	2044	2044	2043	2043	2042	2042	2040
					$t = 600°$ C.							
Vol. % CO	29.00	21.95	18.14	15.11	13.62	11.74	10.55	9.72	9.09	8.00	7.52	5.96
" CO_2	14.00	18.70	21.24	23.26	24.25	25.51	26.30	26.85	27.27	27.84	28.31	29.40
" H_2	57.00	59.31	60.62	61.31	62.13	62.75	63.15	63.43	63.64	64.00	64.16	64.76
" Combustible gas	86.00	81.26	78.76	76.42	75.75	74.49	73.70	73.15	72.73	72.00	71.68	70.60
Thermal value	2632	2487	2410	2338	2318	2279	2255	2238	2226	2203	2193	2160
					$t = 800°$ C.							
Vol. % CO	49.20	48.29	46.91	45.66	44.60	42.65	41.06	39.74	38.61	36.09	34.88	29.76
" CO_2	0.53	1.14	2.06	2.89	3.60	4.90	5.96	6.84	7.59	8.94	10.08	13.49
" H_2	50.27	50.57	51.03	51.45	51.80	52.45	52.98	53.42	53.80	54.97	55.04	56.75
" Combustible gas	99.47	98.86	97.94	97.11	96.40	95.10	94.04	93.16	92.41	91.06	89.92	86.51
Thermal value	3049	3025	2997	2972	2950	2910	2906	2851	2828	2786	2752	2645
					$t = 1000°$ C.							
Vol. % CO	50.00	50.00	50.00	50.00	50.00	49.62	49.62	49.32	49.07	48.92	48.68	47.55
" CO_2	.....	.....	.....	.....	.....	0.25	0.25	0.45	0.62	0.72	0.88	1.63
" H_2	50.00	50.00	50.00	50.00	50.00	50.13	50.13	50.23	50.31	50.36	50.44	50.82
" Combustible gas	100.00	100.00	100.00	100.00	100.00	99.75	99.75	99.55	99.38	99.28	99.12	98.37
Thermal value	3060	3060	3060	3060	3060	3052	3052	3046	3041	3038	3033	3015
					$t = 1200°$ C.							
Vol. % CO	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	49.62	49.62	49.62
" CO_2	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.25	0.25	0.25
" H_2	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.13	50.13	50.13
" Combustible gas	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.75	99.75	99.75
Thermal value	3060	3060	3060	3060	3060	3060	3060	3060	3060	3052	3052	3052
					$t = 1400°$ C.							
Vol. % CO	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
" CO_2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
" H_2	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
" Combustible gas	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Thermal value	3060	3060	3060	3060	3060	3060	3060	3060	3060	3060	3060	3060

We will now consider again the reaction between the outer gas layer and the inner steam current. In working according to the "Gegenstrom principle," the steam of the inner surface can react with the outer gas layer, so that CO is oxidized to CO_2 and H_2 is liberated. Supposing the temperature remains constant or decreases, the thermal value of the gas remains unchanged. If, however, the average temperature of the gas current rises—which is probable, since the gas comes into the hotter parts of the producer—this reaction decreases and the actually occurring improvement in the quality of the gas cannot be explained but by oxidation of glowing coal by means of the CO_2 and the steam of the outer layer and also by the outward diffusion of the steam.

If we work according to the "Parallelstrom principle" the hot outer layer formed in the start will react vigorously on the steam (on account of the higher temperature both the diffusion and velocity of reaction will be greater) and the gas without practical change in thermal value will get richer in H_2 and poorer in CO. Hereby the quality of the gas is improved, just the same as above, by the reaction of the outwardly diffusing steam with the glowing coal. On the other hand, the gas quality is deteriorated as the steam gradually comes in contact with cooler coal, whereby the quantity of CO_2 is increased.

Undoubtedly the first mentioned way of gasifying is more advantageous, the more so as herein the gas and steam current is also preheated gradually.

If we consider the average composition of water gas, in case the state of equilibrium is not reached, we always find this relation between CO_2, CO and H_2, that the volume of H_2 is equal to the sum of the CO volume and double the CO_2 volume. Besides this some steam is also present. The composition of the wet water gas as well as of the dry gas will, therefore, under all conditions correspond to one equilibrium, which, however, at the same steam pressure corresponds to another ("the ideal") gasifying temperature, the latter being—similar as with generator gas—lower than the actual gasifying temperature.

Dr. Hugo Strache and R. Jahoda have studied the influence of height of fuel and air and steam velocity on this process, both during hot-blowing and gas making, and have found:

In the beginning of the hot-blowing period (when the temperature of the fuel is rather low) CO_2 is formed almost exclusively without any CO, while with increasing temperature the formation of CO increases. We have here again the equilibrium which was mentioned before: $2CO \rightleftarrows CO_2 + C$.

As less C is absorbed by a certain volume of air for the formation of CO_2 than for the formation of CO, the fuel consumption is considerably less in the first stages of hot-blowing

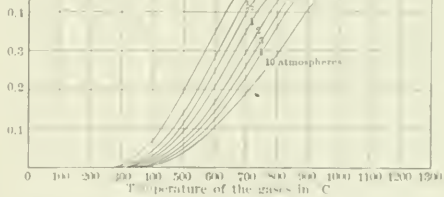


FIG. 6.—KILOGRAMS OF CARBON GASIFIED BY 1 CUBIC METER STEAM

than in the later stage, while the quantity of heat developed per minute is very much greater in the start than in the later stages.

The loss of heat by the hot gas leaving the producer increases with the temperature. The heat accumulated in the producer

is evidently equal to the difference of generated and lost heat. The ratio of accumulated heat and carbon used is called by Strache the efficiency in hot-blowing." This ratio is high in the beginning (at low temperature) and decreases with increasing temperature and fuel consumption.

Content of CO_2 and efficiency in hot-blowing are as follows:

	Efficiency.	CO_2
625° C	80%	18 %
672° C	70	16
920° C	40	7.6
1300° C	30	4.6

The total efficiency for a certain blowing period decreases rapidly between 650° and 900°, it is therefore advantageous not to raise the temperature and the producer above 900°.

The losses of heat during the hot-blowing period can be utilized to a large extent for preheating the steam (in the manufacture of pure water gas).

The losses during gas making depend on the velocity of steam and the temperature of the producer. Too low velocity yields a rather small quantity of gas and causes comparatively great loss of heat by radiation; too great velocity is disadvantageous on account of the steam going through undecomposed; in this case large quantities of heat leave the producer without being utilized on account of the high specific heat of steam.

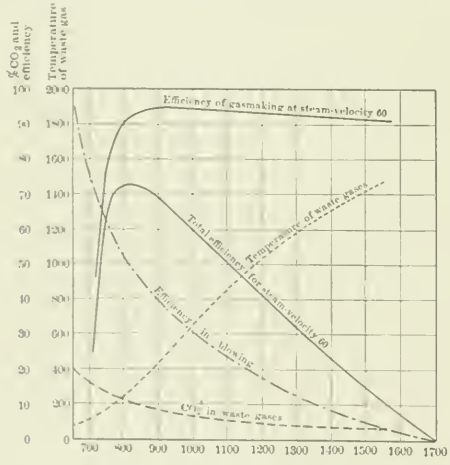


FIG. 7.—EFFICIENCY CURVES.

The results of these researches are:

(1) The quantity of undecomposed steam and the CO_2 content of the gas increase at constant temperature with the increasing velocity of the steam in about the same proportion.

(2) The content of steam and CO_2 of the crude gas at constant velocity of steam decrease with increasing temperature.

(3) Even at low temperature the content of CO_2 and steam can be reduced to a minimum by decreasing the velocity of steam.

The efficiency in gas making is calculated from the carbon consumption during gas making, loss of heat in the producer and the thermal value of the water gas produced. The loss of heat is composed of the heat of formation, heat of the gas produced and of the undecomposed steam and the radiation of heat from the producer. For every temperature there is a certain velocity of steam with which a maximum efficiency is reached (87 per cent to 93 per cent).

The total efficiency for any given velocity of steam can be calculated from the carbon consumption during blowing and gas making, and from the loss of heat during blowing and gas making.

Fig. 7 shows a diagram of these conditions.

The total efficiencies also show a maximum at a certain velocity of steam.

At 780° C..... 72.5 per cent.
At 800° C..... 77 per cent.

The Electric Furnace in Iron and Steel Metallurgy

The interest which the subject has at present is indicated by the number of papers which are being written concerning it. Five of special interest are herewith abstracted.

Dr. R. S. Hutton, of Owens College, Manchester, England, recently discussed the matter in an able paper before the Sheffield Society of Engineers and Metallurgists. The introduction of his paper contains some interesting data on the cost of power. Several figures are given on cheap water power, varying all the way from $20 at Niagara Falls down to an alleged rate of $3 per horse-power-year in Norway.

In discussing steam power the results of electric central stations are generally taken into consideration, but the author points out how wrong this is for electrometallurgical work. The question of power generation on a large scale, for continuous use at full load and on the spot, without the cost of distribution, is entirely different from central station practice. There is no doubt that the subject has been greatly prejudiced by invoking, for the sake of argument, the costs of municipal and other stations, few of which attain more than a 30 per cent load factor. This is particularly important in estimating the capital costs (interest and depreciation) per unit.

As to what can be done in practice, "there seems to be every possibility that in a power plant properly designed for the purpose, and with a small number of large units, in favorable situations, with cheap coal, and with a good water supply, the kw-hour can be obtained by steam at the total inclusive cost of about 0.5 cent." "There are in this country (England) several large private plants running under these conditions, and so far as can be gathered from the evidence of those connected with them (see *e. g.*, Minutes of Evidence of Royal Commission on Coal Supplies), the actual cost in practice is not materially above this figure."

From figures given by the Power Gas Corporation the author states that in the case of a Mond ammonia-recovery gas plant working continuously with a steady load, with coal at $2 per ton (the gas being used for power and heating purposes), the total cost of electricity (excluding interest and depreciation) produced by means of six 300-hp. gas-dynamos, amounted to only 0.2 cent per kw-hour. The same company, as a result of its extensive experience, estimates the cost with a 3,000-kw. plant, working 132 hours per week, and with coal at $2 per ton, at 0.126 cent per kw-hour total working costs, or 0.210 cent total cost, inclusive of interest and depreciation charges. "Whilst the latter figures may need to be taken with some reserve, it must be remembered that in this country (England) there are several electrochemical works with a steady and continuous load in which large gas-engine installations have been adopted in place of a previously equipped steam plant working under very economical conditions."

With regard to the problem of iron ore reduction in the electric furnace the author gives a review of the results obtained at Sault Ste. Marie (our Vol. IV., pp. 124, 265, 332). "Although these developments have no immediate bearing on our own (England's) industries, they most certainly deserve the attention of those who are interested in the development of our colonies, and practically as in Canada far too much is left to the enterprise and capital of the United States."

With regard to steel processes the author first gives a review of the development of the Kjellin induction furnace, and then

speaks on the Heroult furnace. Concerning the latter he makes the following remarks:

"The very fact that the process seems so contrary to general practice merely shows that it is attempting something which has previously been impossible. The inventions of Bessemer and Thomas and Gilchrist appeared in exactly the same light to the vast majority of our manufacturers; but, nevertheless, some were found to carry the invention forward to practical success. Should the Héroult steel process succeed in justifying its claims, there is no doubt that it would be the greatest advance in the general principles of steel manufacture which has been brought forward since the introduction of the basic system."

After a brief description of the process the author points out that the two main features of this process which call for special attention are the purification and the recarburization. In considering the possibility of completely removing phosphorus and sulphur by the action of basic slags, care should be taken to note how very different are the conditions of working from those which exist in the open-hearth process. Here a comparatively thin layer of slag is brought to an exceedingly high temperature. This highly-superheated slag and the metal immediately underneath it are brought into intimate contact, and also caused to rapidly circulate by the convection currents which are set up as a result of the large quantity of heat rapidly transmitted to them. In these facts and in the system of renewing the slag at intervals will probably be found the explanation for the very low values to which the phosphorus can be brought.

The recarburization and the final condition of the steel are also very different from what is met with in the open-hearth process. In its present form the Héroult furnace is so completely protected from ingress of air that the basic slag in the finishing process contains quite a considerable amount of calcium carbide. This not only proves the high temperature to which the slag is taken, but also gives very strong evidence for the absence of air. The whole atmosphere in the furnace above the slag consists of practically pure carbon monoxide and the regular production of metal free from dissolved oxide, and with the minimum of occluded gas, is not only possible but is actually accomplished in practice.

The paper is concluded by a few notes on the steel furnaces of Keller, Girod and Stassano.

* * * *

Two papers on the electric furnace in steel metallurgy were presented before the Verein Deutscher Eisenhüttenleute at their recent December meeting. They are abstracted here from the *Iron and Coal Trades Review*.

Dr. EICHHOFF spoke on the Héroult process as operated at Remscheid, Germany (our Vol. IV., p. 363). He stated that in the largest furnace yet built there for 5-ton charges, the power required to produce a ton of steel still amounted to 750 kw-hours with a cold charge of scrap. If, however, the raw material was melted according to the open-hearth or basic process, and then transferred in a liquid condition to the electrical furnace, the consumption of energy in such a small furnace would be from 200 to 300 kw-hours, according to the desired purity of the material. The consumption in larger furnaces would diminish.

The question was, however, quite different when special steels were concerned. In the case of a tipping open-hearth furnace on the Wellmann system, a charge of from 1½ to 2 tons of liquid steel, which had been more or less purified, was removed, excluding the slag, and placed in the Héroult furnace and then treated. It was possible to make a charge in an hour and a quarter corresponding to a power consumption of 200 kw-hours per ton of steel.

The great heat of the arc, in the opinion of the author, was the ground for its being possible to effect the far-reaching purification and deoxidation, and the original apprehension that the heat might injure the steel had not been fulfilled. The bath was always in brisk circulation, and the individual parts of the same were only exposed to the high temperature for a short time.

As to the works at Remscheid, the plant was started on Feb. 17, 1906, and the demand for the steel produced had become so large that it had been necessary to arrange for the doubling of the installation. As a consequence, an order had been given for a new generating plant of 1,000 hp., a second furnace and a large rolling mill.

Hitherto interruptions had occurred in the Wellmann furnace used for melting purposes, although these could be obviated by the necessary experience. The electric furnace was at work to-day with the same hearth as was built in at the beginning.

As far as working expenses were concerned, the author mentioned that the furnace required two men and a youth, but if cold material was employed it was necessary to add the services of from one to two chargers, according to the size of the furnace. The electrode consumption cost from $0.75 to $1.00, according to the furnace size with a cold charge, and from 25 to 60 cents with a liquid charge, while the consumption of limestone and ore was not greater than in other processes. The use of ferro-manganese and ferro-silicon was largely economized, and the cost of repairs and fireproof material was much less than in the case of an open-hearth furnace.

Mr. ROECHLING then spoke on the induction furnace, and stated that it is possible to remove in the same at will and completely sulphur, phosphorus, etc., in an easy and favorable manner. The peculiar sphere of the process is not melting but rather the improvement of liquid material. "As to the cost of the system, it has repeatedly been possible at Volklingen to completely degasify ordinary basic steel, and to remove phosphorus and sulphur to mere traces, all with a consumption of from 150 to 200 kw-hours per ton. This result was obtained with a small furnace of 600-pound capacity."

* * * *

Mr. JOH. HÄRDEN presented a paper before the Sheffield Society of Engineers and Metallurgists on the electric induction furnace. After a short review of the history of the subject, in which he mentioned the names Ferranti, Colby and Kjellin, he characterized the induction furnace as a transformer with a single secondary winding. He emphasized very strongly that any arrangement in which the primary coil is so placed that the individual windings do not come as close as possible to both the core and the secondary, must involve a bad power factor, and he claimed that Kjellin, who has patented placing the primary coil right in the center, near to the secondary and close to the core, thus obtains the best power factor for this type of furnace.

As to what can be done in the induction furnace the author stated that the furnace is only a modified crucible furnace. High-grade raw material, as used hitherto, must still be used for producing high-class steel. It is not commercially possible to make high-class steel from inferior material, notwithstanding laboratory assertions to the contrary.

The suitability of the electric induction furnace for producing big crucible quality ingots for crank shafts and axles was then pointed out, and the considerable saving in cost over the ordinary crucible furnace was shown.

* * * *

Finally, a paper by Mr. J. W. EVANS presented to the Canadian Mining Institute, shall be recorded, describing some laboratory experiments in which the author endeavored to make steel directly from iron ore.

Several laboratory furnaces are described, and the scale of experiments is indicated by the statement that in the present electric furnaces of the author an ounce of iron ore is reduced in from 15 to 20 minutes and converted into steel.

As to furnace linings, it is said that carborundum or corundum mixed with 8 per cent of tar, when thoroughly baked,

[illegible] very satisfactory lining, although it must not come in contact with an arc charge. An inside lining of magnesite overcomes this difficulty. Charcoal was used throughout as reducing agent in the experiments and limestone as flux.

In treating the sulphurous iron ores over 92 per cent of the sulphur was slagged off, and by varying the amount of lime better results should be obtained. In treating the titanium iron ores steel was produced which did not contain a trace of titanium, but as the writer wished to retain a portion of the titanium the quantity of lime in the charge was reduced, and the result showed that the titanium contents in the steel can be readily governed in this way, although the temperature of the furnace will have to be kept as constant as possible."

The electric furnace process is also said to solve the question of treatment of magnetic iron sands, of which there are large deposits in both Ontario and Quebec, and "the writer has made a mild steel containing .05 per cent carbon from magnetic sands from the St. Lawrence River. These sands could be dredged and dried, magnetically separated, and conveyed direct to the furnace at a considerable saving in cost over mining and crushing iron ore."

When much lime is used as flux, titanium slags off readily. If titanium is retained in the steel, by lowering the amount of lime a large portion of silicon is retained also.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent)

THE FARADAY SOCIETY.

The first meeting of the winter session of this Society had a distinctly chlorous atmosphere. Not in its physical sense, but in a literary sense. The first two papers both dealt with the electrolytic hypochlorites, and the discussion thereon entirely crowded out any discussion on the third paper. The first paper, by Mr. W. Pollard Digby, upon "Some Investigations Relative to the Depreciation of Electrolytically Produced Solutions of Sodium Hypochlorite" was described in outline by the author, whereupon Dr. F. Mollwo Perkin, who was in the chair, called upon Mr. Charles V. Biggs to read his paper upon the "Hermite Electrolytic Processes at Poplar." (Both papers are abstracted on p. 7 of this issue.—ED.)

A combined discussion being called for, Mr. Spiers read a communication from Mr. J. B. C. Kershaw of a rather scathing nature. Mr. Biggs had paraphrased in an appendix a few lines from Mr. Kershaw's article in the April issue of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY. This paraphrase did not suit Mr. Kershaw, who thereupon repeated in exact words the opening column of the article in question, including his theory of the chemical reactions taking place during electrolysis, a theory differing *in toto* from one by Dr. W. R. Hodgkinson (of Woolwich Arsenal), which the author had quoted. Mr. Kershaw closed with an attack upon Poplar administrative extravagances, citing the Hermite installation as a typical example on account of its poor electrochemical efficiency as compared with that of certain Continental processes.

Dr. R. H. Hutton, who followed, asked for particulars as to the size and shape of electrodes, length and weight of platinum wire, the durability of the zinc, and for one or two tables in Mr. Biggs' reply giving the relative costs of salt and electricity per kilogramme of available chlorine at various current densities. He remarked that Mr. Kershaw's point as to electrochemical efficiency as the one desideratum was inapposite. Anybody could show high efficiencies with saturated saline solutions, and Mr. Kershaw's figures were for a process using a saturated solution.

Dr. Alexander next made a very pleasing speech, detailing many minor points which had needed attention in working the process. He referred to an earlier controversy between Mr. Kershaw and himself, and scored notably upon the point of cost. In addition to street watering during hot weather, they had distributed the hypochlorite liquid freely in all cases of infectious diseases. Excluding the cost of labor, which was now actually less than when coal tar disinfectants were purchased in bulk and diluted for distribution, the local authority had only expended £22 in eight months as against £314 for the twelve months of the preceding year. Only unskilled labor was employed. As to the durability of the zinc cathodes, the Netley plant was still at work with its original zinc cathodes. They secured stability at Poplar by adding an excess of caustic soda to the final product, and their liquid was certainly stable. With regard to Mr. Digby's paper, his own view, and also that of Monsieur Hermite, was to the effect that the presence of salt occasioned instability. Monsieur Hermite was now producing, by a secret process, a stable liquid containing a pure hypochlorite of magnesium, and without any chloride whatever.

Dr. Rideal, speaking as a chemist and bacteriologist, gave some reminiscences of the early Hermite and Woolf and recent Atkins' processes in this country, alluding specially to the loss occurring in the presence of easily oxidizable organic matter. He considered that the electrolytic hypochlorite produced *in situ* had a great many advantages in bactericidal activity over chloride of lime.

Further, to quote the cost of chloride of lime per ton free on rails, and to draw deductions from this, was not fair, as it overlooked transport charges, cost of mixing, dealing with sludge, handling of returned empties, etc. Given a suitable electrolyser, what could be simpler for municipal purposes than to turn on a tap, put some salt in a tank, and switch on the current?

Such plants were immediately available for many emergencies. Much could be done by them in regard to street watering. For instance, if the highly deliquescent calcium chloride was used and part of it sent through an electrolyser, it not only laid the dust, but also sterilized it—a very important matter hygienically.

As to the earlier processes, these had certainly been costly, but then the fault was to be found in the large amount of salt which remained undecomposed in the electrolyte. The best process in the future from the chemist's point of view, and also the best commercially, would be that using the smallest quantity of chloride per kilogramme of available chlorine. In the case of the sterilization of a sewage effluent entering a water supply, a minimum of chemical substances should be used. As for Mr. Digby's paper on stability, he was afraid that, despite long investigations, Mr. Digby did not know much about what really caused instability. Nor, for that matter, did anybody else. Perhaps the amount of alkali present was a vital factor in the case. He (Dr. Rideal) was inclined to regard high temperature during manufacture as of little importance.

Dr. Borns, referring to Mr. Digby's paper, asked for information as to how the galvanic couples which had been cited as occasioning exceptional depreciation had been arranged. With regard to the depreciation, due to ebonite, perhaps a sulphide had been formed, which, when present in minute quantities accelerated the depreciation, due to the metallic surface.

Mr. L. A. Smart dealt with the potential value of hypochlorite processes as station-load equalizers, but asked for a less efficient process as consuming more current.

Mr. Wolf Defries emphasized the importance of economy in salt consumption. Salt had been constant in price for quite a long time, and there was no great prospect of a decline. The cost of electrical energy had not yet reached bed-rock prices. As for calcium chloride, which could be had at a fairly cheap rate, they must remember that new uses were being continuously found for so-called "waste products." As for Dr. Alexander's pioneer work at Poplar, he had really rendered a public service, the outcome of which was far more hopeful than the prices mentioned by Mr. Kershaw or Mr. Hutton would indicate.

The authors then being called upon to reply, asked for permission to do so in writing, owing to the lateness of the hour.

Dr. A. C. Cumming's paper on "The Electrochemistry of Lead" was taken and read, discussion being deferred until the next meeting. Dr. Cumming thus secures priority of publication over a Continental scientist who is at work upon the same subject.

CASTNER-KELLNER ALKALI CO., LTD.

The report for the half year which ended Sept. 30 last, states the net profit for the last six months is £35,946, to which has to be added the amount brought forward from last account, £14,548, making a total of £50,494, and after deducting debenture and other interest (£4,071) there remains an available balance of £45,523. The directors now recommend that £15,000 be apportioned to depreciation reserve, increasing that account to £130,000, that a dividend at the rate of 7 per cent per annum be paid for the six months, leaving to be carried forward £14,773. The new works at Wallsend-on-Tyne are now working satisfactorily. This marks a very pleasing advance, and indicates that one electrochemical industry at least—the manufacture of alkali and bleaching powders—is flourishing in the districts once regarded as the sole provinces of purely chemical processes.

METALLURGICAL PAPERS READ IN NOVEMBER.

The papers read at the meeting of the Institution of Mining and Metallurgy, held on Nov. 15, were two in number. The first, by Mr. T. C. Cloud, was descriptive of the Wallaroo Smelting Works, in South Australia. The installation in addition to the smelting of copper has various subsidiary departments. Copper sulphate works, capable of turning out about 500-600 tons of sulphate per annum; sulphuric acid works, with an output of about 5,000 tons of chamber acid per annum; a department for the smelting of refractory gold ores, using copper as a collecting material, and, combined with this, an electrolytic depositing plant turning out about 12 tons of copper per week; and also an electrolytic plant for parting gold and silver.

The ores treated in the smelting works consisted of, for the most part, chalcopyrite (copper pyrites) mixed with varying proportions of pyrite (iron pyrites). A small proportion of the ore from the Moonta Mines consisted of bornite, and occasional parcels consisting chiefly of copper glance were received. Generally speaking, the ore from the Wallaroo Mine carried a larger proportion of pyrite than that from the Moonta Mine. The chief minerals forming the gangue of the ore are quartz, felspar, biotite, hornblende and calcite, while apatite and scheelite also occur in small quantities. The ore, as received at the works, is either (a) hand-picked and broken to about 2½-inch gauge, or (b) jigged concentrates or slimes and fines, the proportions being about 13 of (a) to 20 of (b).

The ores under the heading (b) are oxidized copper ores, consisting of green carbonate and cuprite, with occasional parcels containing a large proportion of the copper in the form of atacamite and ores consisting chiefly of bornite and copper pyrites, comparatively free from iron pyrites. The oxidized ores here referred to come to hand for the most part as hand-picked ore, broken to about 2½-inch gauge, while the sulphide ores mentioned reach the works as jigged concentrates and slimes.

The paper contains descriptions of the *calcining plant* (which is divided into two sections, one dealing with the rough ore, and the other with the jigged concentrates and fines); *the ore* smelting plant containing reverberatory furnaces with beds 23 feet 3 inches by 18 feet 9 inches; *the roasting department*, which is equipped with two revolving calcining furnaces, three large roasting furnaces, the beds of which are 20 feet by 13 feet 6 inches, and seven smaller furnaces; one calcining furnace serves the three large roasters, and the second calcining furnace is connected with the smaller ones.

The refinery department, which is furnished with three refining furnaces, two of which are kept at work with the third in reserve. The charge of "rough copper" is about 12 tons, and the coal consumed 0.4 ton per ton of refined copper produced. There is nothing of note to mention in connection with the actual furnace operations here, as the work is conducted in the manner usual in a plant of this size, the copper being ladled into the moulds by hand. The only special point to which attention should be called is that the copper cathodes from the electrolytic refinery in connection with the gold and silver department are added to the charge.

The following are the most usual forms in which the refined copper is cast: Ingots, weighing 14 pounds; "medium cakes," weighing about 40 pounds, made specially for the Indian mints at Calcutta and Bombay, and for the Cossipore Shell Foundry; and "cakes" weighing 1 cwt. As a check on the work of the refinery, the chief chemist makes an electric conductivity test of each furnace charge, and unless this is satisfactory, the charge—after ladling—is put on one side and an analysis of the copper is then made to determine whether the defect is due to an excess or deficiency of oxygen, or the presence of too high a proportion of nickel. If the latter is found to be the cause of the low conductivity, the copper is sent back to the roasting furnaces and put through again in small quantities at a time with the other charges. If the examination shows that the fault lies in the quantity of oxygen present, the charge is passed through the refining furnace a second time. It is, however, not often that the copper is thus condemned; the management has prided itself on keeping the quality of the copper as uniform as possible, and any charge which departs from this uniformity is treated in the manner described.

The electrical conductivity test is admirably suited for this work, as it gives a definite numerical result, and with suitable appliances it is easy of execution. During the second or third round of the ladling a special test piece is cast, and this is carefully drawn down by the smith to a short rod about 9 inches long by ¼ inch diameter. One half of this is then drawn down on a wire-drawing bench, with occasional annealing, finishing through a sapphire die to wire about 0.025 inch diameter. After a final annealing and cleaning the electrical conductivity is carefully determined against a standard coil. The second half of the rod is kept in that form after being labeled and is available for future reference. The electric conductivity of "Wallaroo" copper is kept at about 88 per cent; if it falls below 86 per cent it is not passed.

The second paper read at this meeting, by Mr. L. A. F. Swinney, dealt with the "Tavener Process," the notes giving in detail the entire working at one of the largest mines in the Rand for the smelting of zinc-gold slimes, from the drying of the slimes to the ultimate production of gold bullion. The figures given pertained to a specified actual smelt from start to finish.

MARKET PRICES DURING NOVEMBER.

Prices have ruled very high indeed in regard to the raw materials of chief interest to engineers, owing to the steadily maintained activity of the engineering trades.

Copper sulphate is firm at £31 10 per ton. Shellac is slightly easier at 215s. per cwt., and Para rubber unchanged at 5s. 2d. Platinum is quoted at 150s. per ounce, and seems likely to go higher.

Copper reached £104 about the middle of the month, but closed firm at £102.10 on Nov. 30. Zinc has been in great demand, best sheets fetching £32.15 per ton. Lead, after rising 5s. to £19.17.6 per ton, declined 2s. 6d. to £19.15. Tin has been fairly steady, closing at £197 per ton, cash.

A sudden spurt in iron has raised the price of Cleveland warrants to 62s. 1d. per ton, an increase of 1s. 11d. since Nov. 24, and 4s. 4d. since Nov. 14. Steel rails and plates are naturally firmer.

LONDON, Dec. 5, 1906.

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

Gol

Cyanide Works Clean-Up Practice.—The proper equipment and arrangement of cyanide clean-up plants has often not received the consideration it deserves, and in order to bring the subject to discussion, Mr J. E. Thomas embodied his views in a paper read before the Chemical, Metallurgical and Mining Society of South Africa. The paper is published in the transactions of that Society for December. Mr. Thomas thinks that the clean-up floor should have a separate drainage from the rest of the extractor house floor, so that any washings should not be contaminated with oil and grease from the pumps, and may be run into a sump from which the residue, after settlement, may be easily collected and included in the next clean-up. He also finds it better to have two acid treatment tubs of a certain capacity than one of the same total capacity, as with the two tanks the one may be fed, while the other is threatening to boil over. When there is only one tank, nothing can be done until this has stopped. A stoppage of the acid tanks throws the whole clean-up back and the time lost cannot be made up. In beginning filter-pressing he has always found that it is much more quickly done when the gold slimes are drawn from the bottom of the washing vat than when the suction from the filter press is slung over the side of the vat. As the gold slimes are very heavy, he advises the use of a specially short length of hose for the filter press pump suction. If, when running down the charges from the acid treatment tubs, everything is put through a 64-mesh screen and the contents of the washing vat are kept in agitation while the press is being filled, there is no danger of the rose over the suction drain pipe becoming choked. He also recommends the use of filter papers over the cloths of the filter press, as the filling is thereby facilitated and the life of the cloths is prolonged, no scrubbing being required to clean them. For washing the cakes, he advises the use of hot water, not only on account of its better washing effect, but because the cakes can be got out dry, even if there is only a layer of gold slimes on the papers or cloths. He also thinks it essential that a vat large enough be installed to take all the washes from the washing vat and the filter press, so that the washes may receive further treatment before being run to waste. He states that gold is present in solution in the acid washes, apparently redissolved by hydrocyanic acid. It is, therefore, advisable to have the washes slightly acid, and then to sprinkle zinc fume over the surface, meanwhile keeping the solution agitated. This should be done each time a charge from the acid tubs is transferred for washing. After the clean-up is over, it is advisable to have the contents of the large vat for the washings assayed, after good settlement and if necessary, more zinc fume can be added before the solution is run to waste. By this means, he claims, the gold in acid washes run to waste may be reduced to 0.07 dwt. per ton, while the ordinary acid washes will probably carry 1.5 dwt. or more per ton. This method is used in all the mines of the Consolidated Gold Fields group. Mr. Thomas also mentions that the motion of the stirring gear for the acid-dissolving tubs should be reversible, as it is often found expedient to reverse the direction of stirring in order to help the dissolving of the zinc and to free any which may have collected around the upright carrying the paddles.

Treatment of Gold-Zinc Slimes.—A description of Clark's gold refining process, communicated to the *Journal* of the Chemical, Metallurgical and Mining Society of South Africa, by Mr. H. T. Brett, Sabiwa Mine, Rhodesia. The slimes may be preliminarily treated with dilute acid, thus removing the bulk of the zinc and other metals with soluble sulphates. If much calcium carbonate or hydroxide is present, a treatment with dilute hydrochloric acid can be given. The slimes, which need not be thoroughly washed, and should not be dried, are then moistened with a solution containing niter cake dissolved in sulphuric acid. Thus when the mass starts to dry on being heated, the sulphuric acid will become more and more concentrated, oxidizing and attacking the metals. The niter cake enables this operation to be carried out at a higher temperature than could be done with sulphuric acid alone, while the mass also sinters into a cake, which can easily be heated without dusting or loss of gold. The temperature of this operation should be a visible red, and the material when cold should be of a reddish or brownish color without any black patches; the action up to this stage denotes the destruction of the cyanides and ferro-cyanides, sulphides and reducing compounds. Most of the metals have been converted into sulphates and mercury and selenium have been expelled. The next operation aims at collecting the gold together in a form easily dealt with mechanically. While the fused mass is still hot, lumps of clean niter cake are added, preferably in instalments and in such a quantity as preliminary tests have shown to give the best results. The smaller the amount taken the more coherent is the cake of gold and the quicker is the heating over, but the separation may not be so thorough and the washing out of the soluble salts takes longer. If, on inserting an iron rod into the fused mass and withdrawing it, the portion sticking to it cools to a dirty brown mass, the gold has not properly run together, but if the cake on the rod on cooling appears white to greenish, or bluish-white between patches of spongy gold, the action is complete. The fused mass may be poured on a cold iron plate and broken into lumps. For the washing the author prefers to use a box, divided after the manner of the zinc precipitation boxes, a filter cloth below and one in the next compartment. Cake is put into 1 and 3 compartments, hot water trickles into 1, runs through the cake and carries fine suspended particles into 2. These are prevented from escaping by the filter above 2, and so on with the others. The solutions escaping would thus be saturated with silver sulphate when they passed out at the end of the box, and the silver could be precipitated by using a similar box filled with iron or copper or both, say copper in the first and iron in the last. Washing is to be continued until the whole of the silver is removed, there will remain with the gold sand, lead sulphate, some calcium sulphate and sometimes oxide of tellurium and basic sulphate of antimony. In order to avoid production of slags, the author recommends amalgamation of the gold. The sponge gold, free from sulphate of silver, can be readily amalgamated with mercury. The amalgam can be retorted, and if small amounts of impurities were reduced, they are easily gotten rid of by heating the retorted gold in clay pots, adding a small quantity of chlorate of potash and a little common salt. When the latter has melted and run through the porous cake of retorted gold, small pieces of dry, solid niter cake are added, and when the action has ceased, some borax can be poured in, when every trace of base metals will be found to be eliminated and even small quantities of silver removed.

Treatment of Zinc Box Precipitates.—The economic treatment of precipitates obtained in the zinc boxes where the gold is precipitated from the cyanide solutions, is a matter of considerable importance. Mr. S. J. Truscott, in a paper before the Institution of Mining and Metallurgy, London, describes the method adopted at the Redjang Lebong Mine, Sumatra, as well as the manipulation of the tilting furnaces in which the

refined precipitate is smelted. The plant contains six zinc boxes, three for the solution from the sands and three for that from the slimes; each box has eight compartments, 36 x 15 inches x 20 inches deep. The precipitation plant is cleaned up twice a month.

One box is cleaned at a time, the solution being displaced by the introduction of water into the top compartment. When the displacement is complete, the zinc in the first four compartments is washed each in its own compartment, and passed over to drain on an adjoining box. A plug in the bottom of each compartment is then opened, and the precipitate, fine zinc and water, pass into the receiving tank, at the entry to which a screen separates the short zinc. The coarser short zinc still remaining in the compartment is then collected in buckets and washed by a water spray in a revolving trommel of 20-mesh screen slanting over the tank. When the first four compartments are finished the washed zinc is returned to them and the remaining compartments are treated in a similar manner. The cyanide solution is then run on again, fresh zinc being added to the lower compartments. The level of the water in the receiving tank is kept down by a small pump, which forces the water through a 20-cell Johnson press, the cells being 24 inches square and 3 inches deep. When all the cells are finished, the solution is pumped out down to the thick slime; the precipitate contained in the press is then returned to the receiving tank. The precipitate in the receiving tank is then treated with acid, the action being aided by a stirrer. When the action is complete, the tank is filled with hot water and the mixture stirred, after which the solution is pumped off through the press. More water is then introduced and the treatment repeated until the water shows no further acidity with litmus paper, after which all the precipitate is drawn into the press and discharged ready for calcination. The short zinc is meanwhile treated similarly with acid in its own tank, and then transferred to the receiving tank for washing as above. The consumption of acid is 0.117 pounds per pound of precipitate, and 0.514 pound per pound of short zinc. The precipitate is calcined in 500-pound lots upon an iron tray over a wood fire at low heat. The material has the following composition: Gold, 8.19 per cent; silver, 58.10 per cent; selenium, 3.56 per cent; zinc, 5.9 per cent; lead, 3.8 per cent; silica, 3.96 per cent; iron, 0.91 per cent; copper, 0.7 per cent; MnO, 0.12 per cent, and undetermined, 14.76 per cent. With clean precipitate, borax is sufficient for fluxing, the charge being precipitate 100 parts, borax 16 parts. With less clean precipitate the proportion is: Precipitate, 100 parts; borax, 17.8 parts; bicarbonate of soda, 9.0 parts, and sand, 0.7 parts. When it is expected that matte will form scrap iron is added; the latter is invariably the case when smelting the short zinc, and it occurs occasionally with the precipitate. This matte consists mostly of silver selenide, as shown by the following analysis: Gold, 0.51 per cent; silver, 66.86 per cent; selenium, 24.10 per cent; copper, 5.22 per cent; iron, 0.99 per cent; zinc, 0.65 per cent; lead, 0.31 per cent; undetermined, 1.36 per cent The two tilting furnaces for melting the precipitate have given much satisfaction, and compared with ordinary pot smelting in single furnaces they greatly reduce the amount of manipulation and there is no loss by dusting, spitting or frothing. The furnaces consist of box-shaped castings, provided on two sides with trunnions carried in bearing on iron standards; the tilting is done by worm and wheel gearing. The retort sits at an angle of about 30° upon an arch of fire-brick some inches above the level of the fire-bars, its neck protruding slightly through the front casting of the furnace. The latter is 1 foot 10 inches x 1 foot 10 inches x 3 feet high, the inside dimensions of the retort being: Mouth, 6½ inches; middle diameter, 13¾ inches; bottom, 9½ inches; length, 30 inches. The top of the furnace is covered by three loose arches. The initial amount charged into the retorts is 150 to 200 pounds, more being added when this is partly reduced, until about 250 to 300 pounds are reached. This is then completely reduced, the slag run off into slag pots and the metal poured into molds of about 640-ounce capacity. The fineness of the bullion for a period of six months was 126.86 parts of silver and 818.54 parts of gold, selenium up to 3 per cent being also found, and small amounts of copper, lead, zinc and iron. During the smelting, purple fumes of selenious dioxide, tinged with selenium, are very noticeable, in such quantity that much is deposited in a pipe generally kept at the mouth of the retort for the purpose of drawing off these fumes.

Sand Sampling in Cyanide Works.—The important question of the most reliable method for taking samples of treated and untreated sand in cyanide plants has been investigated by Mr. D. Simpson, at the New Goch Gold Mining Co's mill on the Rand. He communicates his results in a recent paper before the British Institution of Mining and Metallurgy. The plant in question contains sixteen vats arranged in two lower and two upper rows; they measure 40 feet in diameter by 7 feet 6 inches deep to the filter mats. The upper settling tanks are filled by means of hose delivering the pulp from a central distributor, while the sand is afterwards transferred to the bottom tanks by shoveling through seven doors. The first method investigated was the taking of samples by the so-called sampling rod, a wrought iron pipe 7 feet 6 inches long by 2 inches internal diameter, slit along one side to within 6 inches of the T-handle. Samples were taken haphazard over the surface of the settled sand. The author states that assay results from the samples thus obtained were so irregular and varied to such an extent when taken from the same charge, that this method is unreliable. In the second method samples were withdrawn at points nine in all, with the sampling rod, at equal distances apart, along a diameter. The contents of a 40-foot tank were divided into four parts by weight, by describing on the surface circles with radii of 10 feet, 14.14 feet, 17.32 feet and 20 feet. These divisions should be represented by equal fractions of a proper sample, but marking off nine points an equal distance, 4 feet apart, five are found to be within the inner circle, two within the next, two more within the third, and none at all in the remaining outside circle. Thus seven parts by weight of the sample represent half the contents of the tank and only two parts the remaining half. The author obtained consistent results by this method, but they were consistently high. The third method was to describe the four circles as before, and a line was then drawn across the center of the tank at right-angles to the diameter along which the sampling was to be done. Thus the sand is divided into eight equal parts by weight. Each portion of the sample must then be taken from what may be called the center of mass of each section, namely, in the 40-foot tank a tubeful of sand must be withdrawn at points situated 7.07 feet, 12.2 feet, 15.81 feet and 18.7 feet distant from the center on each side along the diameter, care being taken to insert the rod perpendicularly. This last method, in the author's opinion, is the most trustworthy way in which to take rod samples, as any occasional variation from working accuracy has been, in each case, traced to bad manipulation of the delivery hose In carrying out the fourth method, half the sand was discharged from the tanks, leaving at the diameter a vertical face 7 feet high, which was then divided into seven horizontal zones, each 1 foot wide The face of each zone was scraped into a bucket, and the seven samples were treated individually and collectively. The fifth method consisted in dividing the seven cones formed in the bottom tank underneath the doors of the upper tank, at a certain period during the discharge of the upper tank into quadrants and sampling them with a 2-foot rod The sixth method was carried out by stationing a man in the lower tank, who caught with a spoon what he could, while the material fell down. A seventh method for the discharged material consisted in dropping the heated sand on three conveyor belts, which delivered to a single belt running at right angles. During each complete revolution of the belt a man took a small scoopful of sand as a mark on the belt passed him, and continued doing

...would be taken when discharged. This method is now carried out regularly at the plant for taking discharge samples. In the second method a sample was taken from each tram car, of which the sand delivered by the conveyor was drawn from the bins. The author states that the assays obtained by the latter method were usually the same as those by method seven. The author advises the managers of sand plants, that the occasional resort to such a method as No. 4, and the systematic compilation of the results in tabular form, will repay many times over for the trouble entailed in the value of the index to the treatment obtained.

Silver

The Present State of the Metallurgy of Purely Silver Ores. In a paper read before the recent meeting of the American Mining Congress, published in the *Canadian Mining Review* December, the author, Mr. J. Wilding, intends to call attention to the fact that the metallurgy of purely silver ores has been very much neglected of late years. He reviews briefly the processes for the extraction of the silver from the ores at the place of their production. The amalgamation of raw ores in pans has almost gone out of use, owing to the exhaustion of suitable oxidized ores. The chlorination of the ore, followed by pan amalgamation has the disadvantages of high losses and in most localities of high costs, the losses being partly due to imperfect chlorination and partly to the volatilization of chloride of silver in roasting, which is never less than 7 per cent. and may reach 30 per cent of the silver contents of the ore. Chlorination, followed by leaching with hyposulphite has the same losses as the previous method, and in addition the sulphides obtained have to be further treated, the latter operation, however, being usually compensated by the lower cost of leaching. The Russell process is stated by the author to have generally failed to give satisfactory results with raw ores, and can only be regarded as an aid to the older hyposulphite process in cases of imperfect chlorination. The Patio process still renders good service in a few places in Mexico, being in Pachuca usually preceded and often followed by concentrating out the sulphides and a large part of the small amount of gold contained in the ore. An extraction of as much as 90 per cent of the values is claimed on ore containing 1,500 grams of ore per metric ton, though the proportion extracted from ore of half this grade is much less. Recent improvements introduced into the process are the finer grinding of the ore and the introduction of mechanical devices for turning the ore over in the torta. As far as the use of potassium cyanide as a solvent is concerned, the author states that in cases in which a sufficient proportion of the silver is associated with sulphides removable by concentration, fair metallurgical results have been obtained, even though the proportion of the silver content of the concentration tailings extracted by the cyanide has not exceeded 50 to 60 per cent. As the cost of treatment is not high, the author looks for a further extension of this method for such ores. He closes with a plea to mine owners not to neglect metallurgical research in the treatment of low-grade silver ores.

Iron and Steel.

Magnetic Preparation of Ores.—C. Blömeke, of Aachen, describes in *Metallurgie* of Nov. 8, a new system used by the Hermalthaler Ungarische Eisenindustrie-Aktien-Gesellschaft, in Budapest. The separator is a magnetized steel roll, revolving fast, onto the upper surface of which the material is charged. The speed is so high that centrifugal force plays a considerable part in the separation. On top of the roll non-magnetic material is thrown off tangentially, magnetic material adheres. On the side of the roll, gravity aids centrifugal force in drawing off the material tangentially, and feebly magnetic materials drop off under the combined pull of these two forces. At the lower part of the roll gravity commences to act against centrifugal force, causing particles on the rising side to adhere more strongly, such are removed by a revolving brush, on the ascending side of the roll. A modification of the apparatus, adapted for moist or wet material, has a more slowly revolving, with its lower side immersed in a tank of water, into which the non-magnetic particles will drop as they pass through, while the magnetic particles adhere and are brushed off outside the water bath. Tin ores containing wolframite, similarly treated, had 90.3 per cent of their wolfram removed, saving at the same time 95.0 per cent of the tin.

Graphite Formation.—F. Wust, in *Metallurgie* for Nov. 22, discusses the formation of graphite in cast iron. A series of eight tests, in which the iron stayed liquid 70 to 350 seconds at the eutectic point, 1,130°, showed that the amount of graphite formed is dependent upon the velocity with which the iron passes through this halting point. Those other elements, such as silicon, which are known to increase the tendency to form graphite, *act by prolonging this setting interval;* on the contrary, manganese and sulphur shorten the time of setting, and therefore decrease the formation of graphite. According to this new view it is quite possible to neutralize the effects of such elements as silicon by rapid cooling through the setting point, and of such elements as manganese by slow cooling at this temperature. This was proved by casting an iron high in manganese and low in silicon in a clay mould, which was kept at bright redness, resulting in producing a casting containing 60 to nearly 80 per cent of its carbon in the form of graphite, that is, a completely grey iron, from a material which under normal casting conditions was completely white, and contained less than 5 per cent of its total carbon in the form of graphite. These investigations are of the greatest interest and importance to foundry practice.

The Art of Cutting Metals.—President W. L. Taylor, of the American Society of Mechanical Engineers, delivered an address before that society in New York on Dec. 4, which deserves more than passing comment. The address, as printed, is an epoch-making treatise on this subject, recording with great clearness the results of twenty-six years systematic research in shop and laboratory. The plan of the work was to determine the effect of each of twelve variables entering into the problem, which are stated and discussed as (a) the quality of the metal which is to be cut; (b) the diameter of the work; (c) the depth of the cut; (d) the thickness of the shaving; (e) the elasticity of the work and of the tool; (f) the shape or contour of the cutting edge of the tool, together with its clearance lip and angles; (g) the chemical composition of the steel from which the tool is made, and the heat treatment of the tool; (h) whether a copious stream of water or other cooling medium is used on the tool; (j) the duration of the cut, *i. e.*, the time which a tool must last under pressure of the shaving without being reground; (k) the pressure of the chip or shaving upon the tool; (l) the changes of speed and feed possible in the lathe; (m) the pulling and feeding power of the lathe. The determination of the single effect of each of these twelve variables, keeping the other eleven constant, was a problem requiring the highest technical skill and patience. The practical results attained are classified under four general heads: (A) The codification of the facts or laws connected with the art of cutting metals; (B) the statement of mathematical expressions of those laws simple enough to be suited for daily use; (C) the limitations and possibilities of metal-cutting machines; (D) the development of a slide rule which embodies the application of these laws and expressions to the work of the machinist, enabling him to fix quickly upon the best conditions for each kind of work. The net result of all this work is to take the control out of the hands of the workman and put it into that of the management, thus superseding "rule of thumb" by scientific control.

Etching Fluid for Metallographic Work.—Mr. Kourbatoff, in the *Revue de Metallurgie*, November, states that after visiting the principal metallographic laboratories at the French steel works, he has found that a solution of 4 per cent nitric

acid in isoamyl alcohol is generally employed. The reagent, however, which serves to distinguish troostitic and sorbitic matters is not employed, as it is claimed to give bad results. The composition of this reagent is 1 part of a solution of 4 per cent nitric acid in acetic anhydride, 1 part of methyl alcohol, 1 part of ethyl alcohol and 1 part of isoamyl alcohol. The author claims that the cause of the bad results referred to is due to the use of the acetic acid, properly so-called, instead of its anhydride $(C_2H_3O)_2O$. It is indispensable to employ exclusively the anhydride. Moreover, care has to be taken that the solution is not prepared too much in advance so that the formation of ether is obviated. In order to succeed with the reagent the following precautions have to be taken: Two separate solutions are first prepared, namely, 1, solution of nitric acid with a concentration of 4 per cent, in acetic anhydride; 2, a mixture of equal parts of methyl, ethyl and isoamyl alcohol. At the moment of using the liquid, one part of solution 1 is added to three parts of solution 2. By using nitric acid of 1.32 density the reagent does not produce for the first 10 minutes any coloration on materials other than sorbite and troostite. On the other constituents which remain colorless one observes only some contour of crystals.

Blast Furnace Gases.—In a communication to the London *Engineering*, Nov. 30, Mr. Marcus Ruthenburg proposes an explanation of the indifferent success obtained in the United States in the application of blast furnace gases to the driving of large gas engines. Furnace practice differs materially in the United States and Europe in regard to the temperature of the blast, the ore analysis and the speed of driving, and consequently also in the quality of the effluent gases. He cites the following experience with a Westinghouse three-cylinder engine, with cylinders 15 inches in diameter by 22-inch stroke, running on blast furnace gas of an average of 100 B. T. U. per cubic foot. The blast furnace gas had been passed through the ordinary downcomers and dust catchers, and then through four washers and scrubbers and a meter, before entering the engine. A sample of the gas taken next to the engine at any time was practically free from suspended matter. The engine after running for three weeks continuously was taken down to insert new rings and dress the cylinders. It was then found that the ports, which were normally $1\frac{1}{4}$ inches wide, had narrowed down to little more than $\frac{3}{8}$ inch, on account of a glassy incrustation, which had to be chipped out with a hammer. Upon analysis this incrustation was found to contain every element that had been in the blast furnace charge. As the gas did not show any suspended matter, the author accounts for the formation of this deposit by assuming that the various elements of the furnace charge were dissolved in CO as carbonyls, which carbonyls, being true solutions in CO, and therefore not suspended matter, were not to be removed by filtering or washing. Upon explosion, in which the carbonyls took part, the metals were deposited as oxides in the glassy scale mentioned above.

COPPER.

Pyritic Smelting.—R. Sticht, in *Metallurgie* for Nov. 8, calls attention to the fact that the iron pyrites charged into the pyritic smelting furnace not only loses half its sulphur by volatilization before being oxidized, as is generally assumed, but that his tests show an even lower sulphide than FeS, possibly Fe^2S^4, to be present at points in the furnace where no free oxygen exists. The conclusion drawn is that more heat is evolved in the furnace by the oxidation of iron than from oxidation of sulphur, instead of the reverse being the case. The balance in favor of the iron is even more than Sticht concludes, because he omits to add in the heat of combination of the iron oxide with silica to form slag, which is by no means a negligible quantity.

LEAD.

Condensation of Fume.—K. Friedrich, in *Metallurgie* for Nov. 22 and 29, reviews this whole subject. The two most important factors are cooling of the gas and contact with large surface. For attaining both objects simultaneously there is suggested the use of two chambers similar to Siemen's regenerators. The warm gases pass through one chamber, heating it and depositing fume on its surfaces, while the companion chamber is being cooled by the cold air passing on its way to the furnace; when the first chamber is warmed to its further end, the current is diverted to the second cool chamber, while the first is cooled down in its turn by the cold air. The bricks cannot be in form of checker work, because of the difficulty of cleaning; they are built similarly to hot-blast stoves, with straight passages occupying three-quarters of the available space. Cleaning off is accomplished by water spray running through these chanels, in between two reversals. A modification of this idea is to use a number of such chambers, say ten, arranged circularly like the compartments of a Hoffman brick kiln. The warm current passes, let us say, through 6, 7, 8, 9 and 10, while the cooling current passes through 1, 2, 3, 4 and 5. When 10 becomes too warm the valves are shifted so that the hot current passes through 7, 8, 9, 10 and 1, while the cooling current goes through 2, 3, 4, 5 and 6. By continuing this change, always in the same direction, a very effective cooling and fume deposition is accomplished.

CARBIDES.

Decomposition by Reagents.—C. Hahn and A. Strutz describe in *Metallurgie* of Nov. 8, experiments on the decomposability of carbides. *Calcium carbide* heated to 480° C. and treated by dry steam formed hydrogen, methane and heavy hydrocarbons, leaving a deep black residue, which treated by hydrochloric acid furnished carbon of a peculiar kind. Dry hydrochloric acid gas at 400° furnished a gas consisting principally of hydrogen, with a small amount of heavy hydrocarbons. The melted residue, consisting principally of calcium chloride, furnished also pure carbon on crushing and washing. Dry hydrogen sulphide furnished gas which was almost entirely hydrogen, and the residue, treated by hydrochloric acid, furnished a similar kind of deep-black carbon. *Aluminum carbide* acted similarly to calcium carbide. *Manganese carbide*, acted upon by water acidulated by hydrochloric acid, furnished almost pure hydrogen; dry hydrochloric acid gas gave a similar gas. The residue gave carbon having a luster like graphite, entirely different from the carbon obtained from the other carbides. *Silicon carbide* (carborundum), treated by dry water vapor at 1,300° to 1,400°, gave hydrogen gas with some carbon dioxide similar to a water gas process. The separation of pure carbon under these circumstances was not proven.

PYROMETRY.

Thermo-Elements.—Excellent work is being done in Washington on the subject of pyrometry, notably by the Bureau of Standards and the Geophysical Laboratory of the Carnegie Institution. From the latter a paper by W. P. White has emanated, which is published in the December issue of the *Physical Review*, and in which the author shows that the thermo-element may be made an instrument of highest precision. The main source of error is inhomogeneity. The effect of the initial chemical inhomogeneity is practically negligible, while the effect of physical inhomogeneity—that is the variation in hardness—can by no means be neglected. New wires are usually hard drawn. This hardness as well as that which results from bending, etc., is removed from platinum wires by annealing. On constantan and copper wires a film of oxide or other tarnish is apt to form, which must be cleaned off to restore the original calibration. At high temperatures platinum takes up impurities which diffuse into the wire. Iron and silicon are perhaps the most important. In an oxidizing atmosphere contamination occurs above 900° from the presence of small quantities of rhodium, and especially iridium, either pure or in alloys with platinum. The contaminating impurity cannot be removed, but can be excluded by enclosure in glazed Marquardt porcelain.

MISCELLANEOUS.

Turbo-Blowing Engines.—In a paper before the West of Scotland Iron and Steel Institute, and published in the *Journal* of that Society, October, 1906, Mr. H. M. Brown gives some data concerning the performances of turbo-blowing engines. Engines of this type consist of a turbine air compressor directly coupled to a steam turbine. The latter is of the usual type, and the air turbine consists of a cast iron cylinder in which is arranged a concentric shaft mounted on bearings and revolving at high speed. The annular space between the cylinder and the shaft is occupied by rows of alternate guide and moving blades, the guide blades being arranged on the cylinder and the moving blades on the shaft. Air, on entering the turbine, meets the first row of moving blades, after which it is directed by the first row of guides into the second row of moving blades, and so on, until it reaches the required pressure at the outlet. The efficiency of these machines is very high and the delivery of the blast is steady and continuous. By arranging a by-pass on the steam turbine, by means of which high-pressure steam is admitted to the low pressure of the turbine, the pressure and volume of the blast may be temporarily increased to 40 to 50 per cent above normal, so that a furnace can be blown free if it should be choked. The governing of the turbo-blowing engine is effected by a sensitive centrifugal governor, which actuates the steam admission valves by means of a steam relay. The usual size of the engine is about 20,000 cubic feet of free air per minute, against 10 pounds normal blast pressure when running at 3,000 r. p. m. With the by-pass mentioned above, the speed can be raised to 3,800 r. p. m., and the output increased 50 to 60 per cent, so that either a higher pressure can be obtained or a greater volume of blast. The author states that on account of the steady and continuous blast obtained from such a machine, smelting furnaces are found to be much less liable to hanging or scaffolding. The weight of the apparatus is only 25 tons, as compared with 140 tons for a reciprocating blowing plant. He quotes the performance of a turbo-engine at a large smelting works at Middlesbrough, England, as a typical case. This engine was delivering 18,500 cubic feet of free air per minute, against 10 pounds blast pressure, and took 15,100 pounds of steam per hour. The turbine was fed with saturated steam at 150 pounds pressure, and exhausted into a 27-inch vacuum. The steam consumption was, therefore, only 22.5 pounds per adiabatic horse-power hour, or an over-all thermal efficiency of 37.4 per cent. Another type of machine is arranged for dealing with large volumes at low pressures, and is used for gases from blast furnace plants, pumping and forcing them through the recovery plant. The exhauster is directly coupled to a steam turbine, and its shaft carries three screw propellers, arranged to run at any speed up to 8,000 r. p. m. Between the propellers are arranged stationary guide blades. When higher water gauges than 28 or 30 inches are required, it is only necessary to add to the number of propellers. The author remarks upon the noteworthy point, that these machines, when dealing with blast furnace gases, do not become clogged with tar or other matter, owing to the high velocity of the gas through the machine.

Treatment of Arsenic and Antimony Ores.—A note in the *Mining Journal*, London, Dec. 1, translated from the *Echo des Mines*, Nov. 15, treats with experiments on ores from the Lucette, by the Herrenschmidt process, according to the wet process patent by the latter. The fine antimony ores or the residue from old liquation furnaces are placed in an autoclave with carbonate of soda and lime, or sulphide of sodium or sulphur, carbonate of sulphur (?) and lime, according to the colors intended to be obtained in the finished product. The autoclave is furnished with a plunger, and when the pressure is 5 atmospheres it is emptied by the plunger into settling tanks. The clear liquor passes into coke chambers, as also the sulphuric acid from the roasting furnaces for the antimony ore or the oxide furnaces. Thus the antimony is precipitated now through the filter presses and dried. It is then smelted for regulus or sold for the manufacture of india rubber or colors. The residue is stated to contain the gold which is associated with the antimony. The experiments are stated to have been made on an industrial scale with several tons of ore.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Dental Furnace.—F. E. Roach, 838,047, Dec. 18. Application filed Oct. 11, 1905.

Mechanical details of construction of a dental furnace. A muffle with resistance wires in its walls is placed in the center of a furnace, the free space between the exterior furnace walls and the muffle being filled with asbestos. The article (porcelain, etc.) to be baked is placed on a support in the center of the muffle and means are provided for subjecting the article to more or less heat.

Converting Chromates into Bichromates.—Robert Suchy, 838,757, Dec. 18. Application filed July 9, 1903. Assigned to Chemische Fabrik Griesheim Electron.

A saturated neutral solution of alkali chromate is introduced into the anode and cathode compartments of an electrolytic cell, separated from each other by a diaphragm, employing as electrodes an anode not attacked by the solution (like lead or platinum), and "a cathode which will not reduce the chromate." When electrolysis is started the only anions in the anode compartment are CrO_4, and the anodic reaction is

$$K_2CrO_4 + CrO_4 = K_2Cr_2O_7 + O,$$

that is, formation of bichromate and evolution of oxygen, while in the cathode compartment the K cations form caustic soda with evolution of hydrogen. To keep the voltage low, it is advisable to heat the bath to 80° or 90° C.

Electrotyping.—A. Gerstner, 838,977, Dec. 18. Application filed April 20, 1906.

In electrotyping practice it is usual to submit the wax model, after it has been built up, to the leading process, then polishing the mold, then submitting the mold to the action of a blower for blowing out the superfluous particles of graphite, then submitting the mold to a washing process, then submitting the mold to a treatment consisting in dipping the mold in a bath of copper sulphate, sprinkling iron filings on the mold, and subsequently washing the face of the mold with copper sulphate. All these steps have been usually taken before the mold is stopped off or trimmed and submitted to the action of the battery for electroplating the same. The present inventor endeavors to simplify the process by cutting out a number of the above steps. The only step which is performed after the graphite has been blown out subsequent to the building-up step, is to apply to the mold a solution composed of nitrate of silver (1 ounce), chloride of sodium (2 ounces), and graphite (2 pounds) in water (1 liter). This solution is applied by means of a sprinkling hose attached to a rotary pump connected with a tank containing the solution. The mold is held over the tank, and the solution flows back into the tank after the mold has been treated. The mold is then directly submitted to the electroplating bath, when the coating of silver chloride "will combine with the copper in the electroplating bath to form a metallic silver coating."

Gold Plating.—W. S. Hutchinson, 838,716 and 838,717, Dec. 18. Application filed July 29, 1905.

When an article has been electroplated with gold it is necessary to remove the adhering solution by rinsing in water. The object of this patent is to recover the gold from the washing water. The plating tanks are arranged in two rows, and between them a series of rinsing tanks is provided, and below the latter a series of zinc boxes. Washing water is

passed through the series of rinsing tanks from one end to the other, while the plated articles are rinsed successively in each of the different rinsing tanks, beginning with the rinsing tank furthest away from the entrance of the washing water, and therefore containing the most concentrated cyanide solution. From this last rinsing tank the solution enters the first zinc box just below and then passes through the different zinc boxes, the gold being there deposited and the water, freed from the gold, being used over again as wash water. No. 838,716 refers to the apparatus, 838,717 to the process.

Metallizing Wallpaper.—E. L. Livingston, 838,346, Dec. 11. Application filed Jan. 25, 1906.

The wall paper which is to be metallized on one side only is wetted and laid on a vacuum board. This board is provided with a series of grooves, which are connected by means of pipes with an air pump, so as to produce a partial vacuum. The paper is thus sucked against the board and held flat. Its exposed face is then covered with an adhesive material, such as show enamel or asphalt varnish and a graphite or metal powder, such as copper bronze, is then applied by a brush. Contact wires are then extended along the longitudinal opposite edges of the paper, and the board and paper are then lowered into the plating bath.

Cleaning Storage Batteries.—J. W. Aylsworth, 837,773, Dec. 4. Application filed Sept. 8, 1904.

The object is to remove the very thin and almost invisible films of grease from the interior of the Edison battery (which grease films cause excessive foaming during the charging of the cells). This is done by filling the battery with a weak alkaline solution (about 2 per cent) and maintaining it for several hours at a temperature slightly below the boiling point.

Charging Storage Cells.—I. S. Raymer, 838,583, Dec. 18. Application filed Aug. 23, 1905.

A number of storage cells are sub-divided into various groups, and by means of a special commutator, which is the subject of this patent, it is possible to connect and disconnect, successively, each of the groups of cells to and from their charging and discharging circuits.

Fixation of Atmospheric Nitrogen.—K. Birkeland and S. Eyde, 837,277, Dec. 4. Application filed Nov. 10, 1904.

The patent refers to a modification of their well-known process of fixation of atmospheric nitrogen by arc discharges (see, for instance, our Vol. II., p. 399, and Vol. IV., p. 126). If it is attempted to increase the tension at the arc for the purpose of obtaining an increase of energy as well as arcs with increased surface by increasing the relative distance between the electrodes, the arc will soon be extinguished; i. e., a certain current and magnetic field corresponds to a certain maximum distance between the electrodes. Experience shows that the extinction will always take place when the current is about zero. The object of the inventors' arrangement is therefore to avoid extinction at this point, whereby it becomes possible to increase the tension materially without having to fear an extinction of the arc. Three different methods for obtaining this result are described. They are distinguished as the mechanical, magnetic and electric methods. The "mechanical" method uses one fixed electrode, while the other one *b* can rotate around its axle, as indicated in the upper diagram of Fig. 1. The latter is rotated in synchronism with the alternating current used, in such a way that the distance between the electrode points is a minimum for zero current. The lower diagram shows the use of tubular electrodes, which are especially useful for leading the gases into the furnace through the interior of the hollow electrodes, whereby the latter are cooled. The "magnetic" method employs a pulsating or variable magnetic field, "such pulsation having an effect on the factor of energy substantially equivalent with the variation of the distance between the electrodes." Finally, the "electric" method makes use of an auxiliary circuit, which acts as a bridge for the arc of the working current.

FIG. 1.—ELECTRODE CONSTRUCTION.

RECENT METALLURGICAL PATENTS.

COPPER.

Slimes Treatment—H. N. Thomson and F. Laist (832,176, Oct. 2) patent the following treatment of slimes derived from ore-dressing apparatus operating on crushed copper sulfide ores not previously roasted. These slimes carry more or less silver and some iron, all the metals being in the form of sulfides. The slimes are dried, disintegrated and roasted at a low dull-red heat. The sulfides are thereby changed partly into oxides and partly into sulfates. The roasted slimes are then agitated in a solution of sulphuric acid (2 to 6 parts by weight), ferrous sulfate (5 to 25 parts), and sodium chloride (5 to 25 parts). The copper oxide is thereby changed into sulfate, while the sodium chloride acts as a solvent for the silver, according to the equations:

$$CuO + H_2SO_4 = CuSO_4 + H_2O$$

$$2Ag_2O + Ag_2SO_4 + 12NaCl + 2H_2SO_4 = 6AgCl.NaCl + 3Na_2SO_4 + 2H_2O.$$

To facilitate the solution of the copper during the agitation, air and sulfur-dioxide gases from roasting furnaces are passed through the solution. After filtration the solution is subjected to sulfureted-hydrogen gas, throwing down insoluble copper sulfide and silver sulfide, which are then smelted. The sulphureted hydrogen is obtained from treating a low-grade matte with sulphuric acid.

Converting Matte.—In bessemerizing copper matte in presence of silica, E. H. Hamilton (837,562, Dec. 4) recommends the additions of suitable compounds of the alkaline earths (quicklime, limestone, sulfate of lime or barium compounds) to the molten matte at the time of charging or immediately afterwards and during the blowing of the charge. The effect is said to be in a measure a mechanical one, every available particle of iron sulphids being brought into intimate and quick contact with the silica flux and slagged. This mechanical effect is due to the evolution of gases from the alkaline-earth compounds—such as carbonic acid where lime is used—which have the effect of supplementing the agitating and stirring action of the blast.

ZINC.

Roasting for Wet Process.—A patent of Geo. O. Angell (837,273, Dec. 4) is interesting, since it contains the first authentic information on a new process which is stated to be tried on a rather large experimental scale in a plant in New Jersey. The process is understood to involve leaching and electrolysis, but the chief element of interest is the previous roasting process, which alone is the subject of the present patent. The object is to produce soluble sulfates direct from zinciferous ores which are sulfide blende. The chief endeavor is to prevent the sulfates from being broken up into oxides after the sulfate-forming stage in the treatment has been reached. For this purpose the roasting furnace is closed after the roasting has proceeded so far as to cause the ore to give off and ignite its constituent sulfur gases. Then by admission of air and steam into the roasting chamber the ore sulfides are caused to be sulfated by the sulfur dioxide and trioxide primarily obtained.

Retort Construction.—A. L. J. Queneau, of the New Jersey Zinc Co. (837,883, Dec. 4), describes the construction of a composite metallurgical vessel. The wall is made up of finely-comminuted graphite, suitably mixed with fire-clay and sand

...from the ... that the gaseous products of com... graphite out, leaving the outer ... or porous condition. For this reason the ... with a thick exterior protective layer of fire... and a thinner internal layer of the same material. The ... of the latter is to protect the interior of the vessel ... the ... operation.

STEEL.

Steel-Welding Compound.—G. Wiesmann (837,443, Dec. 4) permits the following compound for welding steel. It consists of 1 ounce saltpeter, 6 ounces borax, 4 ounces brick or ... and 6 ounces of iron scales. When steel has been ... through, being brought to more than a cherry heat, it ... that it can be welded by using this compound equally as ... as ... steel.

NICKEL.

Orford Process.—Robert R. Maffett, of the International Nickel Co., recommends to modify the Orford process for ... and copper separation by using a polysulfide of sodium ... of simple sulfide of sodium. The effect is a great re... in the number of necessary smeltings. The polysulfide ... is simply produced by adding to the usual charge of sodium ... in the cupola furnace 3 or 4 per cent of its weight in ... sulfur.

METAL PRECIPITATION.

Metal-Depositing Apparatus.—W. A. Hendryx (837,832, Dec. 4) uses the apparatus shown in Fig. 1. The solution ... which the metallic values are dissolved is supplied through ... 15 to the revolving cylinder 5, which contains the pre... agent 24 in granular form. For the deposition of ... from its chloride or sulphate, iron or steel scraps or ...

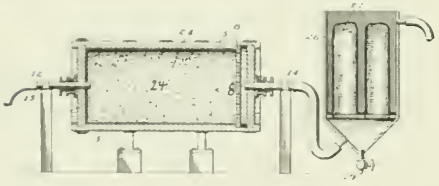


FIG. 1.—METAL DEPOSITION.

... are used as filling material, while for cyanide solu... of gold and silver metallic zinc is used in shot or pul... form. Near the end 6 of the cylinder the screen 8 is ... with apertures of such size as to retain the granular ... material 24, while permitting the free passage of the ... carrying the precipitated metallic values in suspen... The outlet 14 is connected with the lower end of the re... 28, containing one or more filters 27. The precipitated ... are collected in the lower portion of the tank 26, to be ... through outlet 29.

BOOK REVIEWS.

A LABORATORY GUIDE TO THE STUDY OF QUALITATIVE ANALYSIS ... upon the application of the theory of electrolytic ... and the law of mass action. By E. H. S. ... and Hamilton P. Cady. Fifth edition; thoroughly ... 12mo; pp. 278. Philadelphia, P. Blakiston's Son & Co.

It is a great pity that a very good book on qualitative analysis, by experienced teachers, should have been spoiled as this has been by the introduction of scientific gibberish which all the skill of the writers cannot make either clear or useful. The standpoint of the author is clearly expressed in the title, and they have endeavored conscientiously to carry it through, but at the cost of immense inconsistency and almost total destruction of the usefulness of their work as a guide to scientific instruction.

The whole scheme and tendency of the book can be none other than to lead the student away from the simple facts of qualitative analysis, and to plunge him *ab initio* over head and ears into a slough of scientific theory. Subjected to such treatment the unfortunate beginner can develop no independence of thought, no fresh incentive to observation; he is simply tied down to expressing himself in the shibboleth of "a creed outworn."

One of the most insidious tendencies of modern instruction is that of bringing up the young in the narrow lines of a creed or theory. The religious zealot exclaims, "Let me have the children from 6 to 16, and I care not who has them the rest of their lives." Intellectually, children thus brought up are like Japanese stunted trees. The scientific enthusiast says, "Let us instruct the beginner, from the beginning, in our theoretical speculations, and as he grows up he will talk our language and see nature's facts only from our standpoint." Nothing can destroy the freshness of approach, the originality of thought, quicker than these insidious tactics. If we want to develop strong, original, manly investigators, afraid of no fact, because it is nature's fact, and equip them to master natural phenomena, we must teach them from all standpoints; they must *ab initio* be taught to be eclectics.

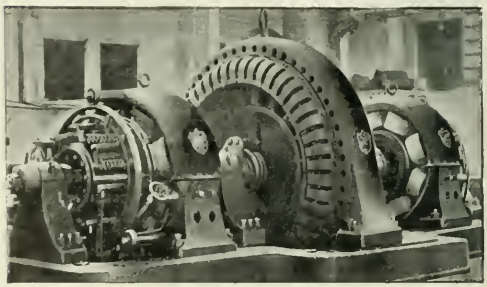
We earnestly appeal to all true teachers, anxious and striving to develop in their students independence of observation, originality of thought, freedom from narrow thinking and broadness of view, to avoid the use of this book—or, perhaps, if a copy finds its way into their hands, treat it as setting forth most clearly how qualitative analysis should *not* be taught.

JOS. W. RICHARDS.

Motor Generator.

The adjoining illustration shows one of three motor generator sets built by the Allis-Chalmers Co., Milwaukee, for the Niagara Electrochemical Co., at Niagara Falls. The electrolytic production of metallic sodium from fused sodium hydroxide must be carried on continuously and a complete shut-down should never occur at any time.

For this reason the set consists of one motor and two gen-



ELECTROLYTIC MOTOR GENERATOR.

erators, and either generator can be disconnected in case repairs are necessary without interfering with the operation of the remaining machine.

The motor is of the synchronous type operated with 25-cycle alternating current at 2,200 volts, the speed being 500 r. p. m. On each end of the motor there is driven by a flange coupling a 200-kw. direct-current generator, the e. m. f. of which is capable of variation through a considerable range, the maximum value being 165 volts.

Automatic Water Still.

Distilled water is a household necessity for drinking purposes in many towns, but it is no less a necessity for constant use in many industrial works. The new water stills described below, made by the Wagner Water Still Company, 87 Washington Street, Chicago, are specially interesting on account of their absolutely automatic operation, since they require no care or attention, operating continuously when the water and gas or steam supply are turned on.

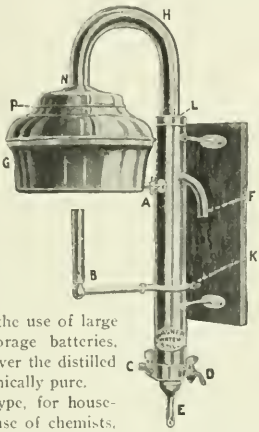


FIG. 1.—WATER STILL OPERATED BY GAS.

The smaller stills are made in four sizes, distilling from ½ gallon to 2 gallons per hour, and are operated by gas; they are made of nickel-plated copper. The larger stills are operated by steam, and are built for capacities of from 100 to 1,000 gallons daily. They are designed especially for the use of large laboratories, for filling storage batteries, etc. Both types of stills deliver the distilled water cold, aerated and chemically pure.

Fig. 1 shows the small type, for household purposes and for the use of chemists, assayers and smaller laboratories. The still consists of a boiler G and a condenser tube, shown at the right-hand of the illustration, both being connected by a high goose neck H—which prevents any physical matter from passing over with the steam under any conditions. C is the water connection while the gas connection is at K, the gas being supplied to the Bunsen burner B. The construction provides for a continuous in-flow of water at C. When it rises to A the boiler G receives water up to a point level with the overflow L. When the water evaporates in the boiler more water is supplied through the inlet A, and a continuous level is thus maintained in the boiler. The cock D is for draining the condenser casing and boiler when the apparatus is not in use.

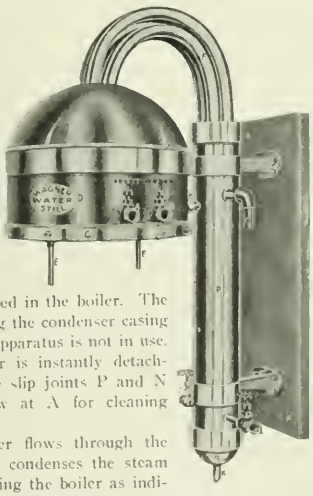


FIG. 2.—WATER STILL OPERATED BY STEAM.

The boiler chamber is instantly detachable by means of the slip joints P and N and the thumb screw at A for cleaning purposes.

In action the water flows through the cock C upwards, and condenses the steam in the tube H, supplying the boiler as indicated and the surplus passing off through the overflow F in a small hot stream. The distilled water drops from the nozzle E at the bottom chemically pure, cold and aerated.

The larger size of the Wagner automatic water still is shown in Fig. 2, the principle being the same as for the smaller type. This larger size is operated with steam, the steam entering through the valve A and leaving through the valve B. The bottom C of the boiler D may be unscrewed for cleaning purposes by means of two detachable brass pins EE. The pins are made detachable so as to prevent the still from being tampered with.

The water enters through the inlet valve J. When it rises to H the boiler is supplied with water to a point level with the overflow G. As the water evaporates in the boiler D more water is supplied through H, thus maintaining a continuous level in the boiler. As the steam passes through the tubes F it is condensed in the condensing chamber P and delivered cold, aerated and chemically pure from the nipple K. R is the collecting cup from the ends of the steam tubes L. All interior parts of the apparatus coming in contact with the steam or condensing water are heavily lined with pure block tin, so that an absolutely pure distillate is delivered. All parts are of heavy polished copper and brass.

The steam coils in the boiling chamber are designed to stand 150 pounds steam pressure, but a pressure of 35 to 60 pounds—or 40 pounds in the average—is sufficient. The water supply through the valve J is so regulated that a small hot stream is delivered through the overflow G, which can be led to a heater tank and used for other purposes.

It is stated that distilled water from this still is furnished at a maximum cost of ½ cent per gallon, and that this cost is very appreciably reduced when the overflow water is used.

Notes.

American Electrochemical Society.—The next general meeting will be held in Spring in Philadelphia, the exact date to be determined later.

New York Section American Electrochemical Society.—The first meeting of the section this season was held at the Chemists' Club on Dec. 11. There were some eighty members in attendance. Dr. Charles A. Doremus, as the retiring chairman of the Section, gave a review of the work of the Society. Mr. van Rensselaer Lansingh then read a paper on the problems of electric lighting from the standpoint of the illuminating engineer. Prof. Samuel A. Tucker, of Columbia, was elected chairman of the Section for the coming year, Mr. Alois von Isakovics was re-elected as secretary and treasurer.

American Association Advancement of Science.—The New York meeting, held from Dec. 27 to 31 at Columbia University, was a full success. Jointly with Section C of the association, the American Chemical Society held its thirty-fifth general meeting. A long list of papers were presented in the sections for inorganic chemistry (H. L. Wells, chairman), organic chemistry (A. S. Wheeler), industrial chemistry (A. D. Little), agricultural and sanitary chemistry (L. L. van Slyke), physical chemistry (Alexander Smith), and biological chemistry (Wm. J. Gies). A special feature were two lectures on Niagara Falls, delivered at the new College of the City of New York. Dr. J. M. Clark gave a review of the legislation tending towards restriction of power development at Niagara, while Prof. C. F. Chandler spoke in a very interesting manner on the electrochemical industries of Niagara Falls, but especially on the aluminium industry. On the evening of Dec. 29 the Chemists' Club tendered a reception and smoker to the visiting chemists. On the same evening Dr. W. F. Hildebrand presented his address as president of the American Chemical Society, the subject being the present and future of the Society.

Niagara Falls as an Industrial Center.—We have received from Mr. Edward H. Taylor, of Niagara Falls, N. Y., a neatly illustrated pamphlet on the natural advantages of Niagara Falls as an industrial center. The booklet contains a great amount of interesting information and statistical data, especially on factory sites, power available, shipping facilities, selling advantages and Canadian trade. The pamphlet should be carefully read by all who are looking for new factory sites with great natural advantages.

The Piqua Blower Co., of Piqua, Ohio, is being incorporated under the laws of Ohio with a capital of $50,000. This company will take over the interests of the Piqua Foundry & Machine Co., Piqua, Ohio, and will make a specialty in the manufacture of exhaust blowers and gas exhausters as developed by the former company in the past two years.

Calendars. The Otto Roesser & Hasslacher Co's calendar for 1906 is a well-done sentimental picture by Woennenberg has received given an artistic reproduction. The calendar of the New York Brick Paving Co. of Syracuse, N. Y., will be received by those who are tired of pretty girl pictures of the Flagg or Christy type; the picture on this calendar shows two boys evidently full of mischief, but in the present case being occupied with torturing a little fox terrier dog by means of a musical performance. A small calendar of the Oxweld-Wilcox Co. gives a view of the works of this company.

Advancing Market in Electrical Apparatus and Supplies.—Prices in the electrical trade continue to show a distinct upward tendency in sympathy with the well maintained advance which has taken place in the prices of all raw materials. Orders for future delivery can only be placed in many instances at a considerable advance over present market quotations. The General Electric Company, in common with many other large manufacturing concerns, is announcing a general advance in prices of electrical apparatus and supplies. This will not unlikely be followed by further advances if present market conditions continue.

The Goldschmidt Chemical Co. has been formed for the purpose of taking over certain chemical processes and patents, other than their well-known thermit process, of Messrs. Th. Goldschmidt, Essen-Ruhr, Germany, and of manufacturing under them. Dr Karl Goldschmidt is the president, Dr. Franz H. Hirschland the treasurer and manager of the company. Mr. L. Stutz and Mr Hubert E. Rogers are vice-president and secretary respectively.

Electric Steel in Germany.—The Oberschlesische Eisenindustrie A. G. and the Poldihutte have decided to introduce the manufacture of tool steel in the electric furnace. The Kjellin induction furnace will be used and the installation will be made by the Siemens & Halske A. G.

Personal.

Prof. J. J. Thomson of Cambridge, and Prof. Henri Moissan of Paris, received this year the Nobel prizes for physics and chemistry respectively. Prof. Thomson has specially distinguished himself through his renowned work in the evolution of the electronic theory, Prof. Moissan through his well-known high temperature research work with the electric furnace.

Mr. Francis P. Coleman, formerly with the Westinghouse and Allis-Chalmers Companies' publicity departments and recently with the Traylor Engineering Co., has joined the Edgerwood Manufacturing Co. as Publicity Manager. Mr. Coleman has also a host of friends from his former connections in an editorial capacity with the New York *Sun* and with *Electrical Age*.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

Carborundum.

No. 492,767, Feb 28, 1893, E. G. Acheson, of Monongahela City, Pa.

Produces a compound of the formula SiC, chemically silicide of carbon carbide of silicon, designated as "Carborundum," a crystalline substance, very brilliant, usually of a dark color, depending upon the materials used, the crystals being in general octohedral, although other well defined forms may be observed. Many of the crystals are opaque, some transparent and colorless, others of various colors. The crystals are extremely hard and highly refractory, withstanding, for a long time at least, an oxyhydrogen blast. The material, in its crystalline or powdered form, is a substitute for diamond powder and bort, for the cutting of diamonds and other gems, and is a suitable abrasive for optical purposes, dental work and grinding valves. It may be formed into wheels or discs, applied to cloth or paper or otherwise put into convenient form for use. An important use is for the filaments of incandescent lamps.

The product may be made by electrically heating a mixture of carbonaceous material, preferably carbon of high purity, with silica or its equivalent, aluminium or calcium silicate, in proper proportion, a flux, such as common salt, being preferably added. Coked bituminous coal or gas coke carbon, preferably of high purity, is properly sub-divided, mixed with silica or a silicate and a flux, such as common salt, the whole mass properly sub-divided and mixed, and the mixture subjected to a high degree of heat in an electric furnace, being placed in the furnace in such manner as to allow the electric current to pass through the mass. Owing to the relatively high initial resistance of the mass, it is sometimes desirable to provide a conducting core, conveniently of graphite, in a loose or solid condition. The furnace illustrated is a rectangular structure, having a flat bottom and vertical slide and end walls of fire-brick, electrodes extending through the end walls, a conducting core being shown between their ends, around which is the charge mixture, filling the furnace.

The specific charge consists by weight of pure carbon, 50 per cent; silica or aluminium silicate, 25 per cent; common salt, 25 per cent. An electric current is passed through the charge, or through the core, if used, the current being preferably increased as the operation proceeds. The charge is thereby highly heated, the flux is melted and the materials react to give the crystalline product. The product is generally found in a zone surrounding the core. The extent of this zone and the character of the crystalline product depend on the character of the charge, the strength of the current, time of operation, etc. During the process chemical combinations and decompositions take place, resulting in the production of gases, vapors and volatile salts, which escape, leaving in the furnace the crystalline product, by-products of graphite and amorphous carbon and a residue only partially converted, representing the various stages of the conversion, and which may form a portion of another charge. The products when removed from the furnace are separated, the carborundum is freed from the graphite and other impurities, broken into small pieces, which may be boiled, washed and dried, and finally be graded into different sized crystals by sifting, or powdered by stamp machines and separated into different grades of powder by floating in water. When the charge consists of carbon, silica and sodium chloride, the average composition of the carborundum is: Silicon, 69.19; carbon, 29.71; oxides of aluminium and iron, 0.38; calcium oxide, 0.19; magnesium oxide, 0.06; oxygen, 0.47.

When the charge consists of carbon, clay (aluminium silicate) and chloride of sodium, the product consists of silicon, 60.51; carbon, 30.09; oxides of aluminium and iron, 4.78; calcium oxide, 0.17; magnesium oxide, 9.18; oxygen, 0.27.

Reissue—No. 11,473, Feb. 26, 1895, E. G. Acheson, of Monongahela City, Pa.

This reissue is in general identical with the preceding patent, but states that it is preferable to work with a core and, specifically claims passing the electric current through a conducting core embedded in the charge.

Electrochemical and Metallurgical Industry

VOL. V. NEW YORK, FEBRUARY, 1907. No. 2.

Electrochemical and Metallurgical Industry

With which is Incorporated Iron and Steel Magazine

Published on the first of each month by the
ELECTROCHEMICAL PUBLISHING COMPANY,
[Incorporated.]
114-118 LIBERTY STREET, NEW YORK.

J. W. RICHARDS, PH. D.....*President*
E. F. ROEBER, PH. D.....*Editor*

Subscription Price: $2 per year, postpaid to any part of the world. Single copies 25 cents.

Copyrighted, 1907, by the Electrochemical Publishing Co.

Entered as Second-Class Matter, June, 1903, at the Post-Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, FEBRUARY, 1907.

CONTENTS.

EDITORIAL 37
Electric Smelting for the Foundry..... 37
Industrial Safety 37
Natural Resources of the United States..... 38
Engineering Prophecy 39
The Iron and Steel Market..... 40
Removal of Sulphide of Zinc Accretions in Reverberatory Forehearths 40
American Electrochemical Society 41
CORRESPONDENCE:
Card Index. By A. L. Voge..... 41
Water Gas. By J. W. Richards and Oskar Nagel 41
Electric Smelting for the Foundry. By R. Moldenke 42
McDonald Electrolytic Bleach and Caustic Soda Plant. By J. B. Crocker 43
Metallurgical Calculations. By J. W. Richards 44
Melting Points of Elements. By J. A. Harker. 48
Chas. Frederick Chandler. By Marcus Benjamin 49
Bleaching Liquors 50
Nitrogen in Iron 51
Faraday Society 52
NOTES ON ELECTROCHEMISTRY AND METALLURGY IN GREAT BRITAIN 53
ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS..... 55
SYNOPSIS OF PERIODICAL LITERATURE. 58
RECENT METALLURGICAL PATENTS 61
BOOK REVIEWS:
J. E. Dowson and A. T. Later, on Producer Gas 66
Niagara Falls Power 66
Multiple Scale Switch 66
Filter Presses for Slimes Treatment 67
Fused Quartz for Pyrometer Tubes and Other Uses in Chemical and Metallurgical Engineering 67
New Balance 68
NOTES 68
PERSONAL 70
DIGEST OF UNITED STATES PATENTS (Carborundum) 71

Electric Smelting for the Foundry

In the iron and steel industry the electric furnace has so far proven commercially successful for two purposes: first, for the manufacture of ferro-alloys; second, for the manufacture of high-grade steel. In the production of ferro alloys the essential reaction is the reduction of the refractory oxide of the metal which it is desired to alloy with the iron; the electric furnace is used here because this reaction requires a high temperature. In the manufacture of high-grade steels the essential reaction is that of melting and refining; *i. e.*, removal of undesirable impurities; the advantage of the electric furnace over the crucible process rests essentially in larger units, more durable apparatus and reduced labor cost. In a highly suggestive letter, published in this issue, a new application of the electric furnace—namely, for foundry use—is proposed by Dr. Richard Moldenke, the distinguished Secretary of the American Foundrymen's Association. Here the action would be essentially one of melting, perhaps coupled with refining. The advantages are very clearly explained by Dr. Moldenke, and we hope his communication will find due attention from both founders and electric furnace men.

◆◆◆

Industrial Safety

At the Museum of Natural History there is held at present an exposition of safety devices, and in general of objects relating to industrial safety and industrial hygiene, under the auspices of the American Institute of Social Service. This is the first undertaking of its kind in this country, and, as a sort of prologue, a banquet was held at the Waldorf-Astoria on Jan. 28, at which the guest of honor, Governor Hughes, delivered an impressive address to a notable gathering. Much was said by other speakers, notably the Italian Ambassador, on what has been done for industrial safety in European countries, especially in Germany, France and Italy. The extensive governmental system of obligatory insurance of all workingmen (in the widest sense) against accident and old age in Germany is now well known, but will hardly be imitated in other countries; it was the means by which Bismarck tried to steal the thunder from the social democrats. Governor Hughes' address, while mostly of a general nature as to the necessity of doing something for industrial safety, emphasized one point which is of importance for the general public, namely, the necessity of greater safety and comfort in transportation. Everybody will probably agree with him in this respect. Perhaps with the exception of the stockholders of some trolley companies, who will consider comfort too much of a good thing, since it is essentially the "strap-hanger" who pays the dividends of stock diluted by H₂O. On the other hand, even from a purely mercenary standpoint, safety in industrial work will appeal to everybody as an absolute necessity.

The present exposition, arranged by the American Institute

... of considerable educational value, ... from a broad and liberal point of ... safety devices of all kinds. But ... industrial hygiene comprises ... to the injured, prevention of ... diseases harmful to the life of ... and devices for supplying and maintaining ... and industrial betterment, etc. Further, and this ... there is a long list of labor-saving ma... The influence of labor-saving ma... the general uplifting of the working classes and ... greater safety in industrial work, resulting there... cannot be over-estimated. The invention and introduction into practice of labor saving machines is specifically American, and may be considered perhaps to be the most important contribution of the American manufacturer to the improvement of the condition of his workingmen. Labor saving machinery is really at the bottom of the great difference between the condition of the workingman here and abroad. In this country the workingman who has to do with labor-saving machinery is really no longer a workingman, but rather an overseer who directs the machines to work for him. It is a remarkable fact that this philanthropic policy of our manufacturers has also been good business policy. It is a fact that, in spite of very much higher wages for labor here than abroad, the cost of labor per ton of output is in many plants quite considerably smaller in this country than in corresponding plants abroad.

* * *

We may be permitted to add a few words on a subject which at first sight seems to have little to do with this matter, but which is in reality intimately connected with it. This is the way in which electrochemical methods have modified in many cases old-fashioned chemical or metallurgical practice. One has only to visit a modern electrolytic caustic and bleach plant and then to visit an old-fashioned alkali plant, and finally to compare notes as to the condition of the laborers in both plants. The electric current is such an effective agent, when properly applied, it does the chemical work so exactly and thoroughly that the workingman has little more to do than to see that he has the current always in exact control. How electrochemical methods may be essentially labor-saving methods is clearly evident in the instance of the electric furnace for making high-grade steel in competition with the crucible process. A distinguished steelman of the old school, who always used to make sport of us when he heard of electric steel, recently told the writer of his visit to an electric furnace plant producing high-grade steel, and described how he was impressed by the great ease of operation, the great reduction of manual labor and of the number of workingmen required. Electric power may be an expensive agent—as all labor-saving machinery is sometimes—nevertheless, it may pay the manufacturer to stand the expense. We quote a few figures from the report of the Canadian Commission on the Kjellin steel process (page 141). If the total cost of making 1,000 kg. of ingots, $37.48, of this amount $2.60, the electrical energy to ... the wages are 7 per cent and the electrical ... per cent of the total cost. Manufacturers using the ... process should compare these figures with the corresponding figures in their own cost sheet.

The National Resources of the United States

Besides the proverbial three essential factors that make for the production of wealth, there is a fourth factor, the "entrepreneur," which, while not generally comprised by the old school of economics in the enumeration, is in this age of applied science of increasing importance. It is well nigh impossible to segregate the relative value of the four parts of the economic machine, but managing and technical skill are most often the cause of the success of any enterprise. The natural resources are, of course, of nearly equal importance for economic well being. As nature deals the cards, so the natives must play. Land is the source of all wealth. The fish from the sea, the wood from the forest, the grain from the field, and the ore from the mine are all first-hand values from Nature's vault. With practically all the requisite raw materials, America is always adequately endowed. For instance, our greatest export is raw cotton. For the needs of the civilized, and especially the semi-civilized world, cotton cloth is nowadays a prime necessity. Climatic conditions of rain and sun are only right for the production of cotton in our Southern States. If we would imagine the cotton crop sold under governmental control by a national board of clear-headed business men, whose public interest in making money for the nation would be as great as is their private interest now, the natural net monopolistic returns to the country would be enormous. Corn and wheat to feed the workers of the country are raised in abundance in the States of the great plains.

* * *

Our agricultural methods are still lax, and the value of the farm lands of the nation will be enhanced in the future. Our forests once could supply much more than our national demand for lumber. But the forests have been rapidly denuded and the demand for lumber has increased inordinately. Consequently, the price has risen to such an extent that concrete, brick and galvanized sheet buildings are used more largely. But with scientific forestry our forest resources will furnish a constant and regular supply. With regard to coal lands, the United States has been blessed above all other nations with the possible exception of China. The Appalachian Mountains, the green plains of the Middle West, the arid deserts of New Mexico are spread with great areas of sedimentary rocks of the carboniferous and cretaceous ages. Included in these formations are veins of black mineral—the stored-up sunlight of past aeons. These coal lands have made Pittsburg, Cleveland, Chicago and Pueblo great smelting centers. The steam engine and the gas engine are machines for converting this potential energy into economic values. But in this age of coal, iron and copper the economic importance of coal is without bound. As the farmer must feed our internal machinery, so the coal miner must furnish the food for our industrial machinery. Our enormous water powers, our gas and oil resources furnish similar pabulum to the industrial body. And the extent of our natural resources for making power will make the electrochemical industry the "Technik der Zukunft."

* * *

In the land of unlimited possibilities the great Mesaba iron mines are a fitting place for the head waters of Niagara. The great value of the self-fluxing ores of Alabama and Tennessee, so close to the industrial heart of the new South, is just now being made apparent. The great copper mines of Montana,

Michigan and Arizona have given America the lever with which to move the copper market of the world. Recent finds in Cananea, Arizona, Utah, Nevada, British Columbia and California show the existence throughout the Cordilleras of a great copper belt. The gold and silver mines of the country are large, but the production of gold and silver is increased by precious bullion recovered as by-product in lead and copper smelting. The zinc mines of the country are large, and the supply of spelter will be greater as our metallurgists improve their methods of treating low-grade lead-silver-zinc ores. Taken all in all we have a precious heritage in our wonderful natural resources. America should conserve them and utilize them with a maximum net efficiency over a long period of years, and not carry out an inefficient maximum production over a short period of years. There has been too much wasteful attack of our inheritance. A wise but restricted paternalism and a free and educated public opinion,—the sheet-anchor of a republic that must be individualistic in most respects will stop this economic "race suicide." Then we will see a more sensible and even development of Nature's bounty.

Engineering Prophecy

Prophets are divisible into two main classes, the prophet pessimist and the prophet optimist. The reason why the prophet is without honor in his own country is because pessimism is the keynote of many prophecies, and no person is more exasperating than the friend whose assertive "I told you so" merely pours corrosive sublimate upon the sores of defeat. The prophet optimist scores in two ways. Optimism is always pleasant, particularly to him who, vexed with the woes of Pandora's box, clings to the remaining gift of hope as his only solace. At such times the optimist reaps his reward in immediate popularity as a jolly good fellow. Later, if the prophet optimist's views are vindicated, there comes the further reward of being hailed as far-sighted. If immediate vindication does not result he can, if he has fixed no time limit for himself, claim all futurity for his prophecy to come true. The prophet pessimist stands to lose all round in the esteem of his fellows. Mankind, bewitched by an old fallacy in a new garb, confident of the Dorado or Utopia round the corner, objects to the embittered individual whose dyspeptic forebodings are as grit in the bearings of the axles of progress. That is the first stage in the unpopularity of the prophet pessimist. The second stage has two alternative sides. If the view of those who differed from the pessimist has been more or less vindicated, he reaps his reward in the scorn his contemporaries lavish on his narrow vision. If, on the other hand, the pessimist proves to be right, he will be well advised if he assumes to share the depression which his fellows suffer. Should he be human enough to remark on his own foresight, his unpopularity will be even greater than in the first stage.

* * *

In the realizations of engineering progress, time has confounded both optimist and pessimist alike. More often than not the pessimist has been the worst confounded. The optimist, on the other hand, is often aghast at his previous moderation, and wishes that he had advanced speculative views of greater daring in the first instance. Yet, despite the dangers of prophecy in its social sense, it is necessary that in discussion of engineering problems, in papers presented before scientific and technical institutions, the prophetic note in the scientific sense should be struck. Not the note of the romancer of the Jules Verne school, but rather the forecast of the seer who has traveled some little distance along the road through a wilderness of difficulties towards a promised land; in short, towards the Utopia round the corner. The broad division between pessimist and optimist may be applied, however, to most of these cases, except to such addresses or papers as are the retrospective history of a year or a decade of progress. The bias must, on the whole, lie towards optimism, though it requires more courage to be pessimistic. For this means that the speaker tends to stake his repute on a negation, and his thesis often implies an accumulated burden of fruitless endeavor before the boundaries confronting him were declared insurmountable. Moreover, engineering precedent shows the pessimist as more frequently wrong. Certain unfortunate precedents have furnished ready weapons wherewith the modern pessimist is assailed. These are so notorious that they need not be cited.

* * *

Yet, as a simple point in the law of evolution, no continuous rate of progress to any goal endures for any period at the same momentum. Temporary accelerations in the direction of motion are at times afforded, while other forces either retard or divert that motion to right or left. In science progress has recently been so rapid that according to all natural laws something may be said for the anti-optimistic school, and a period of slower apparent progress and a longer assimilative period given to the development of stamina may intervene. As for the prophet optimist, him we do not propose to advise. But to the prophet pessimist we would suggest that he should not declare progress in his sphere to be impossible because for the moment the river cannot be forded. Rather should he be moderate in his pessimism, nay, even be an optimist. While declaring, and often quite truly, that with the facilities at his command immediate progress along one path may be checked, he might reasonably safeguard himself by declaring that with further progress by others along allied and parallel paths, that which is insurmountable to-day may yet be bridged by help to be secured in the future from other wings of the army of science. Much has been done by a harking back to a branching of the ways traveled, and attacking the closed door with the instruments and appliances of a later day. As to tangible reward for the prophet pessimist we do not see much that is agreeable. He may, however, do most useful service with less unpopularity if he refrains from declaring that progress is impossible and will admit a saving clause into his prophecy. As to the reward of the prophet-super-optimist, we do not know if he needs any. Virtue (or an assumption of it, which amounts to the same thing) is said to be its own reward. We may leave the prophet optimist to his idols and ideals, chimeric though the latter may seem. But so far as the future of a striving and virile race goes, we probably owe more than is generally conceded to the prophet pessimist. The very negation must in such a race spur the workers to greater striving. An affirmative forecast is not always soul-inspiring to an energetic race, although it may serve to soothe a generation of short-sighted serfs, just as opium soothes its emasculated devotees.

The Iron and Steel Market.

The situation has not lost a particle of its strength, and the iron and steel market continues to be the strongest, in point of tone and steadiness, which has ever been experienced. The United States Steel Corporation reported that on Dec. 31 it had 8,480,718 gross tons of unfilled orders on its books, which is the largest yet reported at the quarterly periods, and shows a gain of 552,834 tons for the quarter, a gain of 884,432 tons in a year, and a gain of 3,793,515 tons in two years. During January orders were heavier than shipments, so that there has been a further gain, but as buyers are now well covered it is probable that the tonnage on March 31 will be somewhat smaller, unless, indeed, books are opened for 1908 rail orders, in which event a further increase may possibly be shown.

There have been few changes in prices of finished steel products. Effective Jan. 24, galvanized sheets were advanced $2.00 per net ton, galvanized corrugated roofing 10 cents per square, and blue annealed sheets $1.00 per ton. The advances in galvanized products were due to the high price of spelter, which towards the close of January reached 6.85c., New York, against an average price during 1906 of less than 6.25c. Outside of a short-lived boom in 1899, the present spelter market is by far the highest on record. Effective Jan. 25, merchant steel pipe was advanced 1 point or about $2.00 per net ton, making the "official" price on jobbers' carloads 75 per cent off list, on sizes ¾ to 6-inch, inclusive, the actual market on large lots being 76 and 5 off. This is the third 1-point advance since the 2-point advance Oct. 13, making the total advance about $10 a net ton. Independent tin plate mills are booking third quarter business at 10 cents a box above the regular market, the leading interest not making regular sales for third quarter, and this points to a general advance in tin plate before long.

Advances have been quite general in the past four months, putting finished steel products, with the exception of shapes and rails, up from $3.00 to $10.00 per ton. Soon these advances will begin to be felt by consumers; at present practically all material is going out on old contracts. The advances are sufficient to exert an influence in the direction of curtailing consumption, but in the present alignment of the market the universal feeling is that if there is any impending danger it is that of financial troubles or general business uncertainty, with a continuance of fairly satisfactory conditions in this respect the iron and steel market seems certain to carry itself well through the present year.

Sooner or later a depreciation must occur in the iron trade, whether mild or severe remains to be seen. It is becoming increasingly difficult to finance undertakings. A symptom of the underlying conditions as regards the financing of railroad improvements is found in the arrangements made by the Pennsylvania Railroad Co. early in January, by which it has authorized $100,000,000 of car trusts, to be issued in series of $10,000,000 each; twenty-five of these series are to cover cars ordered for 1906 delivery, and nineteen are to cover cars ordered for 1907 delivery. Most of the 1906 cars are already delivered, yet these certificates are to be issued some time in the future, and the railroad expects to purchase a part of them itself, retaining them in the treasury until a better opportunity is afforded to dispose of them to the public. If the greatest railroad system in the world has such difficulty in financing cars already ordered, and largely delivered, it certainly will not be easy for other railroads to finance all the expenditures they may be willing or even anxious to make.

Pig Iron.

Early in January some fairly heavy buying occurred for second half delivery. The market later became uneventful. Towards the close of the month two apparently opposing currents became apparent; in the East prompt pig iron was offered at concessions, and sellers appeared anxious to make sales, while at the same time in the Central West and the South there developed fairly heavy buying for second half at full prices. In the ultimate analysis it will probably be found that the easier tone in prompt iron was but the natural adjustment called for by conditions, since so great a spread between prompt and future deliveries could of necessity be but temporary. The indications are that the pig iron market will be strong for the greater part of the year. The engagement of iron for import has about ceased, although a fairly large tonnage is yet to come in. The Jones & Laughlin Steel Co., at Pittsburg, is embarrassed, as early in the month its No. 2 Eliza furnace broke out, causing the loss of several lives and necessitating an indefinite suspension, while towards the close of the month it was decided to blow out No. 5, as it was slipping badly, and another accident was feared. This leaves it with only about 65 per cent of its normal capacity in blast, and the pig iron market is such that it is impossible to purchase any adequate quantity. The valley (Mahoning and Shenango) market stands as follows: No. 2 foundry, prompt, $25.00; second half, $21.50 to $22.00; Bessemer, $22.50 for nearby delivery, $22.00 to $22.50 for second quarter, and $21.50 for second half; basic, 25 to 50 cents less than Bessemer; prices delivered Pittsburg, 85 cents higher. In the South, Sloss, Tennessee and Republic are holding for $19.00 for second half, while there are a few sellers at $18.50. Feb. 1 the Southern roads advanced their rates 25 cents to Ohio River points, while the Northern roads made an advance of 20 cents to certain points. The rate from Birmingham to Pittsburg is now $4.85; to Chicago, $4.35; to New York the rail and water rate advanced 25 cents to $4.25.

Billets and Sheet Bars.

The market has become a trifle easier. Shipments on regular contracts by the large interests are improved, while some of the smaller interests are offering steel. The new open-hearth steel interest on Staten Island, Milliken Bros., is offering some steel; the Portsmouth (Ohio) Steel Co. has offered some steel, and the Republic Iron & Steel Co. and the Youngstown Sheet & Tube Co. appear to be offering steel somewhat more freely. We quote Bessemer billets on the basis of $29.00 f. o. b. Pittsburg, and open-hearth billets on the basis of $30.00 f. o. b. Pittsburg, although it is possible that the steel could not actually be put into Pittsburg at these figures. Sheet bars can be had for forward delivery at $29.50 f. o. b. Youngstown.

Finished Steel.

We quote finished steel prices as follows, unchanged from last report, except in the case of galvanized sheets:

Standard rails, 50 pounds and heavier, $28.00 at mill, except that Cambria and Pennsylvania are obtaining $30.00 on early delivery; light rails, $34.00 in carloads and $33.00 in large lots f. o. b. Pittsburg, for sections 25 to 45 pounds.

Structural shapes, 1.70c. for beams and channels, 15 inches and under.

Plates, 1.70c. for ¼-inch and heavier, for indefinite delivery; as high as 2c. is obtained by the smaller mills for quick delivery.

Merchant steel bars, 1.60c. base.

Sheets, 2.60c. for black and 3.75c. for galvanized, No. 28 gauge; blue annealed, 1.85c. for No. 10 gauge.

Tin plates, $3.90 for 100-pound cokes.

Removal of Sulphide of Zinc Accretions in Reverberatory Forehearths.

Where a reverberatory forehearth is used entirely independent of the lead furnace to separate out the last globules of metallic lead and copper-lead matte from the slag, the sulphide of zinc separates out from the slag and "mucks up" the tap-holes as sometimes the entire hearth. The exact

nature of the process is not known, but probably the zinc sulphide is carried in "igneous solution"—at least a convenient term if not an explanation—and thrown down in the oxidizing atmosphere and lower temperature of the forehearth. An easy practical way to remove these accretions is to add scrap cast iron. Cast iron is used because of its lower fusion point. This decomposes the zinc sulphide, forming iron sulphide and metallic zinc. The latter boils off and burns with its well-known white fumes. This is used with more or less success by several of the large lead smelters. It is one of the nice little tricks of the trade.

American Electrochemical Society.

The next annual meeting will be held on the 2d, 3d and 4th of May (Thursday, Friday and Saturday of the first week of May), at the University of Pennsylvania, Philadelphia, Pa.

The following gentlemen were elected members at the January meeting of the board of directors: Messrs. B. B. Burling, Lancaster, Pa.; C. L. Speyers, New Brunswick, N. J.; H. P. Wood, Urbana, Ill. At the February meeting of the board of directors the names of the following gentlemen will come up for election: Messrs. S. T. H. Hall, Helena, Mont., and J. Henry Lienau, New York City.

At the next annual meeting, in Philadelphia, there will be a general discussion of problems of a scientific or engineering nature on subjects bearing on electrochemistry. Some time ago the board of directors authorized the secretary to ask the members of the Society for such problems, for the purpose of publishing the same and securing a discussion. There has been quite a liberal response to this request, and the secretary has now published a list of those problems. Part of it is given below. The remainder will be published in our next issue.

Fixation of atmospheric N by electric current.

Production of HCl from electrolytic chlorine.

Decomposition voltages of salts in fused condition.

Conductivity of various fused baths.

Heat formation of alloys and alkaline and alkaline-earth metals with "heavy" metals.

Direct electrolytic separation of Zn from ZnS concentrates, or roasted ZnS. (Fused bath.)

Search for electrode and furnace materials which will resist various fused baths.

Uses of Cl and the several alkali and alkaline-earth metals.

Investigation as to relative melting points of the rarer elements and oxides from 1,200° to 2,800° C.

Anodic behavior of carbon electrodes in relation to the combination of carbon, hydrogen and oxygen—an application of electrochemistry to one of the fundamental problems of organic chemistry.

The mechanism of the reactions which result in ferrate as one of the products of the electrolysis of alkaline chloride solutions and the conditions governing the amount produced.

Are catalytic reactions electrochemical?

The resistance and temperature coefficient of various metals and alloys.

The electromotive forces between different metals and solutions.

Phenomena in a porous diaphragm.

Intermediate electrodes.

Does it take more electromotive force to deposit a liquid metal than a solid metal from an electrolyte?

Electric conductivity of melted metals, at various temperatures.

Preparation of carbon black from natural gas.

Thermochemical data for carbides.

Does the presence of an electrically conducting pigment to a linseed oil paint applied to an iron structure tend to promote corrosion?

The conditions affecting the corrosion of steel and other alloys.

Data with regard to the deterioration of graphite anodes at different temperatures, with different fluxes and slags and with reference to possible specific gravities of the graphite electrodes.

Effect of temperatures (aqueous solutions) on the life of graphite anodes (a) with stationary electrolyte, (b) with circulating electrolyte.

The production of metallic antimony from stibnite.

A further investigation of the ionization of carbon, and experimental work tending to utilize carbon directly for the generation of electricity.

Is the electrolytic preparation of bleaching solution for pulp a success?

An economical method for the recovery, by electrolysis, of the copper contained in the water pumped from copper mines. The composition of this water is as follows: Free sulphuric acid, 0.1200 grams per liter; arsenic, 0.00915; antimony, 0.00570; copper, 0.1573; iron, total, 0.2310. The copper and iron are both in solution as sulphates. Large quantities of this water are pumped from the Butte and other copper mines, and the present practice is to run the water over scrap iron and obtain a precipitate running 50 per cent copper, which is subsequently treated in furnaces with more or less loss.

The behavior of metallic silicon as an anode in chloride solutions.

CORRESPONDENCE

Card Index.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—It seems probable that American electrochemists do not realize the present standing of the proposed card-bibliography of the current periodical literature of electrochemistry which the Concilium Bibliographicum, of Zurich, intends publishing.

The preliminary work towards its production has been completed, but no regular printing of the references has been done.

The Concilium, from its experience gained through publishing other card-bibliographies during a period of more than ten years, knows exactly the cost of their production.

To make this branch—electrochemistry—self-supporting will require seventy-five subscribers to the complete set of cards.

The manuscript of the Section of Electrochemistry will not be printed until this number of subscribers has been secured; but the Concilium will then assure its subscribers of a complete set of references to the original work being published the world over on electrochemistry, and will guarantee that the bibliography will not limp along for a year or two and then cease to exist, but that it will be *continued*.

The Concilium will ask no payments of subscribers until the first half-year's cards have been delivered to them.

If electrochemists of America believe that a card bibliography, arranged minutely by subjects, would be of value to them or to the institutions which they represent, now is the time to act on that belief and to contribute their support by subscribing to this branch of the work of the Concilium.

Communications may be addressed through February and March to the writer at the address given below.

A. L. Vogt.

214 A Street, S. E., Washington, D. C.

Water Gas.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—In your January issue is a translation by Dr. Nagel of Baron Juptner's article on water gas, taken from the latter's "Chemische Technologie der Energien." This letter is written not to criticise the translation, which is well made, but to criticise two glaring errors in the original which remain

translation, and which shall be corrected here.

When carbon burns to CO, 97,000 Calories are generated per 12 kg. of carbon burning (we agree with Jüptner); when a decimeter weight of CO (containing 12 kg. of carbon) burns to CO_2, 68,500 Calories are evolved (we agree again with Jüptner), but when 12 kg of carbon burns to CO_2 Jüptner says that 21,100 Calories are evolved, whereas, from his own figures, just given, and with which we substantially agree, there are evolved 97,600 − 68,500 = 28,000 Calories.

Jüptner should have used 28,000 instead of 21,100, to have his figures consistent with each other; I prefer a slightly different value 20,100, which is 0.9 per cent higher, but there is no shadow of doubt that the figure 21,100 is some 8,000 Calories below the correct figure, an error of 28 per cent.

The second error is that Jüptner takes 60,750 Calories as the heat of formation of a molecule of steam or water vapor, whereas this is the heat of formation of molecular weight of liquid water. When steam is passed over incandescent carbon, steam is the thing decomposed, and not liquid water, and, therefore, the heat of formation of water vapor, which is 58,040 Calories, is to be supplied per molecular weight of steam decomposed. Jüptner's figure is therefore 11,690 Calories too high, an error of 20 per cent.

The fundamental equation of the production of water gas being $C + H_2O = H_2 + CO$, and Jüptner having erred 20 per cent on one and 28 per cent on the other of the heat quantities involved, we can infer that no value at all attaches to his discussion of the thermochemistry of this reaction.

Joseph W. Richards.

Lehigh University, Bethlehem, Pa.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—Referring to Dr. J. W. Richards' letter I would say that the figure given for the heat of formation of CO in the January article is an overlooked misprint. The same figure, however, is correctly given in the October article of last year; furthermore, this mistake does not interfere with the correctness of the rest of the article, which contains a great deal of valuable and original information. Relating to the combustion heat of H_2, Jüptner is using the figure for liquid water; whether this is proper is somewhat a matter of opinion. However, by these accidental mistakes the value of the work, which is considered in Europe the most prominent of its kind, is not at all diminished.

In the translation of the complete work, which is now in preparation, these misprints or mistakes will be carefully corrected.

Oskar Nagel.

New York City.

Electric Smelting for the Foundry.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—For some time past foundrymen have been interested in the developments of electric smelting so far as it might be applied to their industry. As the necessary information as to whether iron may be melted in a commercial way can only be given by our electric furnace friends, perhaps a few remarks on the requirements involved may be of use to those who have apparatus and processes adapted for foundry work.

The average foundryman of to-day has constant calls for steel castings along with his regular routine work in gray iron. This, on account of the rapid introduction of the steel casting into machine construction. These steel castings he must submit to the steel foundries. The latter are looking for tonnage, and do not like to fill up with small quantities of comparatively light work. Hence high prices, which cut the foundryman's profit. In a similar way the foundryman has to deal with malleable castings. The malleable castings founder has both steel and gray iron put up to him, and it may not be long in the future when the steel founder may be asked to produce both gray iron and steel castings along with his steel. It is to be understood, of course, that this is all brought about in making contracts with concerns who place their work by the year, or the thousand tons, be the castings what they may during the period of contract.

Now, very few foundrymen are equipped for this. They strive to place these outside lines with other people at the smallest loss to themselves. Yet if there were a convenient and easily operated process, many of them would install it immediately to take care of just such conditions.

The smelting, or rather plain melting, of iron electrically has always seemed to me ideal in its way. We do not want to produce chemical changes in our mixtures if we can help it. We want only to melt quick, produce very hot iron, and punish the metal as little as we can. Every time we melt the metal under present conditions we hurt it somewhat, the degree of the damage done depending upon a number of conditions, both chemical and physical. We counteract this by additions of steel to reduce the total carbon, or selecting the silicon content in such a way that with the reduction in this element incident to the process, a strong iron results. If, however, we could have a process which in no way changes the composition, we could put into the melt just what we want out of it, and one of the serious difficulties of foundry metallurgy would be solved. Again, if we could regulate the temperature in such a way that the iron is not overheated while melting, but can be heated up very high afterwards, we could obviate the oxidation of the metal during the melt, and in addition remove any existing evil of that kind by the use of ferro-manganese in the melt when it has been brought to practically a steel temperature, at which point the ferromanganese will do its work.

The induction furnace, it seems to me, fills these requirements, and I would like to see more work done along this line for the foundry. I may be in error, but it would seem to me that scrap of all kinds, properly selected, is all that need be melted, cleaned by some ferro-alloy, and then cast in the usual way. The enormous steel production will always yield scrap enough to supply the demand for small steel castings, once a process of this kind can be made to work commercially, and I would be very glad to be of assistance in bringing a process of this kind to the attention of the foundry world.

Taking the non-ferrous metals. A brass foundry would have abundant use for an electric smelting process, if run on the lines laid out above. The melting loss in the brass foundry in zinc and tin is a great one, and one that runs up into money quickly. A clean, wasteless process, as the electrical one should be, would be a boon to the industry. There are many foundries which could melt within short periods of time during the day or night when their plant is not used for its regular purposes. Hence only the electrical apparatus proper might be required, the necessary power being available.

The foundry has practically every melting process under the sun in use for making the various classes of castings. We see the open-hearth, the Bessemer and the cupola, the air furnace and the crucible in operation everywhere. Yet every metallurgist knows that the crucible process gives the best metal, if you can stand the cost. Now, the electrical furnace, if the melting proper is conducted so that the advantages of the crucible process are retained; that is, the temperature not allowed to exceed safe limits, and the metal kept from oxidizing influences, is bound to give the highest class of product, and it seems to me with the greatest ease of manipulation.

I would therefore urge the study of this line of work in contradistinction to the smelting of steel from ore; in other words, to simply melt, instead of completing the cycle of operations in a metallurgic process. The great foundry industry is ready to take this up once the commercial feasibility has been demonstrated, and I therefore present the problem to the electro-metallurgical fraternity with my best wishes.

Watchung, N. J. Richard Moldenke.

McDonald Electrolytic Bleach and Caustic Soda Plant.

By J. R. CROCKER.

The art of producing caustic soda and chlorine gas to satisfy the great diversity of its uses, and its ever increasing consumption in the industrial arts, has demanded the attention of the best talent in the chemical and electrochemical field. Innumerable attempts have been made for producing these products strictly along chemical lines; that process being the most successful where the cost of raw material was the least, or where the by-products could be reclaimed in a manner profitable.

America, unhampered by the more obsolete methods followed in Europe, and with its unlimited resources for pro-

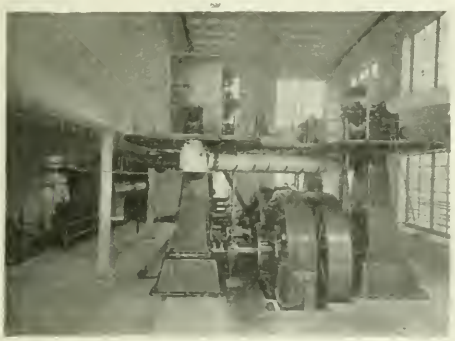


FIG. 1.—ENGINE ROOM

ducing cheap power, was ripe for the introduction of electrochemical methods to enlarge and improve upon the general chemical industry. Therefore, it was not long before this country was industriously pushing to a conclusion the most

FIG. 2.—SWITCHBOARD

effective system pertaining to cheapening the cost sufficiently to compete with foreign trade. Consequently, there have been developed several systems for the production of caustic soda and chlorine gas by the electrolysis of sodium chloride.

Naturally, the most successful is the one where the economy of maintenance and operation, in conjunction with high efficiency, has proven beyond the skepticism of the investor the true facts of its merits. Such a process as this is illustrated herewith in a plant installed by the McDonald Electrolytic Co. for the New York & Pennsylvania Co. at their paper mill at Johnsonburg, Pa. This plant has been in operation for over one year, and has a daily capacity of 10 tons of bleaching powder and 6½ tons of caustic soda.

Figs. 1 and 2 represent the engine room and switchboard. The walls and floors are of tile, and the exposed iron work is coated with white enamel. The generating units are direct-current, compound-wound generators, constructed so that each will operate without sparking at a voltage varying from 180 to 270, and capable of supplying 2,000 amps. to the cell sets arranged in series-multiple. These generators are direct connected to vertical, cross compound condensing engines, with a

FIG. 3.—CELL ROOM ON SECOND FLOOR

rating of 750 hp. at 100 pounds steam pressure at the throttle. The exhaust of these engines is conducted to a condenser. The switchboard is so constructed as to operate the individual cell units independently, their regulation being governed by a separate ammeter to each unit. The auxiliary machinery, such as a motor-generator set for lighting 200 10-c.p. incandescent lamps, and a 100-hp. motor for driving the agitators in the bleach liquor tanks, derive their power from the main units.

Figs. 3 and 4 illustrate the cell rooms. Fig. 3 shows the second floor, containing 250 cells and the chlorination towers, to which the chlorine gas is delivered under a slight suction. Fig. 4 shows the third floor, upon which are located 350 cells. All of these cells are connected up in series-multiple of 50, and so connected at the switchboard as to be interchangeable.

On the first floor are located the bleach liquor tanks, with a

FIG. 4.—CELL ROOM ON THIRD FLOOR

combined capacity of 72,000 gallons of bleach liquor. There are also located at this point the brine mixing and storage tanks. The plant as a whole, as constructed so as to facilitate its operation with as small an amount of labor as possible. The brine solution is supplied to the cells automatically, and the

[illegible] resulting from its decomposition are handled with [illegible] exposure.

The [illegible] gas upon delivery to the chlormation towers is immediately taken up by the milk of lime, and after repeated circulation is brought up to the required per cent of available chlorin, when recaptured it is delivered to its point of consumption by the aid of a system of piping and rotary pumps. The spent salt cake leaves the cells at a density of 15° B., and is delivered to an adjoining building. The evaporator receiving the solution at 15° B., 5 pounds steam pressure concentrates it to

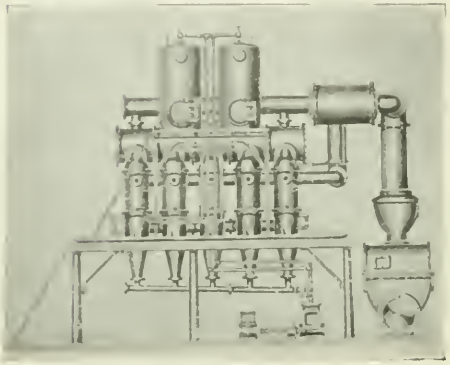


FIG. 5.—ORDWAY EVAPORATOR.

45° B., and during this operation the salt is practically eliminated. By the introduction of this evaporator there is furnished the connecting link to a most complete system for producing a finished product from the raw material.

It has been found by the New York & Pennsylvania Co. that the repairs and replacements on the plant, as a whole, have been abnormally low, and I am told that their cells have been in operation over eight months without being disturbed, and, when finally taken apart, the replacement of the anodes was the only requirement. The results produced by this plant have attracted chemists both in this country and abroad, especially as many tests as to its efficiency have substantiated the claims set forth by its makers.

Metallurgical Calculations.

By J. W. Richards.
Professor of Metallurgy in Lehigh University.

THE OPEN-HEARTH FURNACE.

By the above title we mean to designate not only the regenerative gas furnaces for making steel but also those for reheating purposes; in other words, regenerative or recuperative reverberatory furnaces. Prominent among these is the Siemens-Martin furnace, with complete gas and air preheating regenerative chambers. In all these furnaces the charge is heated, or kept hot, partly by direct contact with the gaseous products of combustion and partly by radiation from the flame and the sides and roof of the furnace. It was the Siemens brothers who first insisted on the relatively great importance of the radiation principle, in distinction to the direct impingement of the flame on the material, pointing out that a luminous flame radiates from all parts of its volume, while a hot, solid body radiates only from its surface, and direct impingement interferes with the development of perfect combustion and consumes heat relatively slowly at best.

Gas Producers.

Gas producers are the usual adjunct for open-hearth furnaces, excepting where natural gas or blast furnace gas is available. They may be placed far from the furnace, when they deliver cool gas to the regenerators, or close to the furnace, delivering comparatively hot gas to the regenerators, or even be made part of the furnace itself, delivering their hot gas immediately to the ports of the furnace. The latter is undoubtedly the most economical arrangement where practicable.

The following generalizations concerning the relations of the gas producer to the open-hearth furnace may be made: Producers furnish 4,300 to 4,600 cubic meters of gas per metric ton of coal used (150,000 to 160,000 cubic feet per short ton); the gas produced runs 3 to 8 per cent CO^2, 5 to 20 per cent H^2, 20 to 30 per cent CO, and 50 to 60 per cent N^2; its calorific power is 750 to 1000 Calories per cubic meter (47 to 63-pound Calories, or 85 to 115 B. T. U. per cubic foot); its calorific power represents 60 to 90 per cent of the calorific power of the fuel used; in steel-making processes, the keeping of the furnace up to proper heat requires the gasifying of 25 to 35 kilograms (50 to 80 pounds) of coal per hour, in the producers, for each ton of metal capacity of the furnace; good producers gasify 60 to 65 kilograms of coal per hour per each square meter of gas-producing area (10 to 15 pounds per hour per each square foot); a furnace therefore requires some 0.4 to 0.6 square meter (4 to 6.5 square feet) of gas-producing area in the producers for each ton of metal capacity of the furnace.

Flues to Furnace.

In conducting the gases to the furnace, the flues or conduits should be of ample size. If too small the gas must pass through them with high velocity, requiring considerable draft to give them this velocity, which the chimney or blower may or may not be capable of furnishing. Producers are almost always worked by a steam blower, furnishing mixed air and steam and a plenum of pressure in the upper part of the producer, which suffices to send the gas through the conduits under a slight pressure, and thus avoids any sucking in of air through crevices in the conduits. With too small conduits the resulting friction and high velocity required may give the blower more work than it can do, and thus entail demands for draft upon the furnace stack. A reasonable rule is to give the flues such cross-sectional area that the hot gas which must pass through them shall have a velocity between 2 and 3 meters per second.

Regenerators.

The dimensions of the regenerators are of the first importance to the working of the furnace. They should have sufficient length in the direction the gas currents are passing, so that the gases may be properly cooled or heated; they should have sufficient cross-sectional area of free space, so that the velocity of the gases through them is not too great; they must have sufficient thermal capacity, so that they can absorb the requisite quantity of heat.

Length.—From 4 to 6 meters (13 to 20 feet) is a suitable length in the direction of the gas currents. This permits the hot products to become properly cooled before going to the chimney, and the gas or air to be properly heated before entering the furnace. The shorter length may be used when the regenerator is of large cross-sectional area, with slow velocity of gas currents through the free spaces; the longer when the regenerator is rather restricted in cross-section and the gas currents have somewhat high velocity.

Cross-Section.—The free-space sectional area should be such that the gases where hottest should not have a calculated velocity of over 3 meters (10 feet) per second, and if calculated for 2 meters (6.5 feet) will give much better results as regards transmission of heat to the checker work. In this manner, knowing how much gas must go through the regenerator and what its maximum temperature will probably be, the cross-section area of free passage space can be calculated. The relation of this to the cross-section of the entire stove must next be considered, and this is entirely a question of how the checker work is built up. If the bricks are stacked close together the free space may be reduced to as much as one-half the total;

as ordinarily stacked it may be 60 to 80 per cent of the total; if perforated bricks are used, as in blast-furnace firebrick stoves, the area of free space averages one-half the total; with ordinary bricks the average is 70 per cent. This is a question which is very variously worked out in different furnaces, and to which not as much scientific thought has been given as should be. The thickness of the bricks influences greatly the relative amount of free space and filled space, and the rate at which the regenerator heats up or cools off. In a regenerator of given length and cross-section closer packing of the bricks gives more heat absorbing surface, increases the velocity of the gases and diminishes the cross-sectional area of each passage and of the sum of all the passages; some of these factors increase the efficiency of the regenerator, others tend to decrease it, and there are, therefore, several independent variables to be considered in finding the best arrangement for highest efficiency. A numerical solution is indeed a possibility, but is too involved for an elementary presentation of the subject.

Relative Sizes.—The relative sizes of gas and air regenerators is a question of importance which admits of easy solution by calculation. So far we have treated the pair of regenerators together, and discussed the sum of their cross-sections as deduced from the volume of products passing through at an assumed maximum temperature and allowable velocity. The regenerators at one end of a furnace are, however, usually divided into a pair or set, one for heating gas and the other for heating air. This is not usual where natural gas is used, because of the deposition of soot in the regenerator by the latter when it is heated, but nine out of ten open-hearth furnaces preheat their gas as well as the air. The heating capacity of the regenerators should be divided in proportion to the calorific capacities of the gas and air simultaneously heated. The problem is therefore to find the heat capacity per degree of the gas and air used, or, more exactly, the total heat capacity of each of these between the temperature at which they enter the regenerators and that at which it is desired that they should enter the furnace.

Problem 66.

An open-hearth furnace uses producer gas containing, by volume, as it reaches the regenerators:

CO	26.97	per cent.
CO^2	4.37	"
CH^4	0.33	"
H^2	13.00	"
NH^3	0.21	"
H^2S	0.10	"
N^2	54.01	"
Air	1.03	"

Each cubic meter, measured at 20° C. and 720 m.m. barometric pressure, is accompanied by 73.22 grams of moisture, as determined by drawing through a drying tube and weighing the moisture. The air used is at 20° C., 720 m.m barometer, and three-quarters saturated with moisture. A maximum of 10 per cent more air is used than is theoretically necessary to completely burn the gas (assuming NH^3 to burn to H^2O and NO^2, and allowing for the air already present in the gas). The gas and air may be both assumed as coming to the regenerators at 20° C., and to be heated in the regenerators to 1200° C.

Required.—(1) The relative volumes of gas and air passing through the gas and air regenerators.

(2) The total amounts of heat necessary to be furnished to each, per cubic meter of gas used.

(3) The relative sizes of the two regenerators.

Solution.—(1) Taking 1 cubic meter of the dry gas, as represented by the analysis, the combustion of its combustible ingredients is represented by the equations:

$$2CO + O^2 = 2CO^2$$
$$CH^4 + 2O^2 = CO^2 + 2H^2O$$
$$2H^2 + O^2 = 2H^2O$$
$$4NH^3 + 7O^2 = 6H^2O + 4NO^2$$
$$2H^2S + 3O^2 = 2H^2O + 2SO^2$$

And since molecules represent volumes, each unit volume of CO, CH^4, H^2, NH^3 and H^2S is seen to require respectively 0.5, 2, 0.5, 1.75, or 1.5 volumes of oxygen. The 1 cubic meter of dry gas therefore requires oxygen as follows:

CO	0.2697	× 0.5	= 0.1349	m^3
CH^4	0.0437	× 2.0	= 0.0874	"
H^2	0.1300	× 0.5	= 0.0650	"
NH^3	0.0021	× 1.75	= 0.0037	"
H^2S	0.0010	× 1.5	= 0.0015	"
Total			= 0.2925	"

Air needed = 0.2925 ÷ 0.208 = 1.4062 m^3
Add 10 per cent excess = 1.5468 "
Air present in gas = 0.0103 "
Air to be supplied = 1.5365 "

Each cubic meter of dry gas, at any given conditions of temperature and pressure, would require 1.5365 cubic meters of dry air at the same conditions of temperature and pressure. This, however, is not exactly the relation required, for the reason that the gas is accompanied by considerable moisture, which in reality adds to its volume, while the air is also moist, adding to its volume. Two corrections must therefore be applied; first, to calculate the volume of the moisture accompanying 1 cubic meter of (assumed) dried gas; the second, to calculate the volume of moisture accompanying 1.5365 cubic meters of (assumed) dry air. Assuming our gas and moist air both at 20° and 720 m.m. pressure, the volume of moisture accompanying 1 cubic meter of (assumed) dry gas is the volume of 73.22 grams of moisture at these conditions, which is

$$73.22 \div 1000 \div 0.81 \times \frac{273 + 20}{273} \times \frac{760}{720} = 0.1024 \text{ m}^3$$

The air being 0.75 saturated with moisture at 20°, the tension of this moisture will be $17.4 \times 0.75 = 13$ m.m. The air proper is therefore under $720 - 13 = 707$ m.m. tension instead of 720 m.m. and the volume of the moist air containing 1.5365 cubic meters of (assumed) dry air is therefore:

$$1.5365 \times \frac{720}{707} = 1.5648 \text{ cubic meters.}$$

The relative volumes of actual (moist) gas and actual (moist) air used are therefore:

$$1.1024 : 1.5648 = 1.0000 : 1.419 \qquad (1)$$

(2) To calculate the heat necessary to raise gas and air from 20° to 1200° per cubic meter of gas used, the best preliminary is to calculate the composition of the gas, *including* its moisture. Since 1 cubic meter of (assumed) dry gas is accompanied by 0.1024 cubic meter of water vapor, the sum being 1.1024 cubic meters, we can calculate the real percentage composition to be:

CO	24.47	per cent.
CO^2	3.96	"
CH^4	0.30	"
H^2	11.79	"
NH^3	0.19	"
H^2S	0.09	"
N^2	48.99	"
Air	0.93	"
H^2O	9.29	"

Of the above quantities the (assumed) dry gas in 1 cubic meter of (actual) moist gas is 0.9071 c.m. The air used for its combustion will therefore be

$0.9071 \times 1.5365 = 1.3938$ m^3 dry air.
$0.9071 \times 1.5648 = 1.4080$ m^3 moist air.
$1.4080 - 1.3938 = 0.0142$ m^3 of moisture

The heat required by the 1 cubic meter of (actual) moist gas is found as follows:

$$Volume \times \frac{\text{Mean Specific Heat}}{20° - 1200°}$$

CO	0.2447		
H^2	0.1179	× 0.3359 = 0.2895	Calories.
N^2	0.4899		
Air	0.0093		
CO^2	0.0396	× 0.0384 = 0.0253	"
H^2O	0.0929	× 0.5230 = 0.0486	"
CH^4	0.0030	× 0.0484 = 0.0019	"
NH^3	0.0019	× 0.5752 = 0.0011	"
H^2S	0.0009	× 0.5230 = 0.0005	"

Mean cal. capacity per 1 ° = 0.3609 "

Total calorific capacity 20° — 1200°
0.3609 × 1180 = 432.9 Calories.

The calorific capacity of the moist air simultaneously heated through the same range will be:

Air 1.3938 × 0.3359 = 0.4682 Calories.
H^2O 0.0142 × 0.5230 = 0.0074 "

Sum = 0.4756 "

Total calorific capacity 20° — 1200°
0.4756 × 1180 = 561.2 Calories.

The air regenerator should therefore have 561.2 ÷ 432.9 = 1.30 times the heating power or cross-section of the gas regenerator; *i. e.*, 30 per cent more. Or the combined capacity of the pair of regenerators should be divided so as to give 57 per cent to the air regenerator and 43 per cent to the gas regenerator. In ordinary practice it is usual to allow about 60 and 40 per cent respectively; it is better to calculate ahead for the specific case in hand, if the composition of the gas to be used is known.

Valves and Ports.

No very exact rule can be given as to the size of the gas and air vlaves, or those leading the products to the chimney. If made too large they are cumbersome to operate and apt to warp, if made too small they give undue obstruction to the flow of gas. A general rule is to calculate the free opening, such as to give the gases passing through a velocity between 3 and 5 meters (10 and 16 feet) per second, allowing, of course, for the average temperature of the gas or air or products of combustion passing through them. It may be remarked that while water-seal valves are very convenient, the water is evaporated where in contact with gas or air, and diminishes the heating efficiency of the furnace, the use of a non-volatile oil or a fine sand would appear preferable to water.

The ports are a very important part of the furnace, and may be designed in many different styles for various ways in which a furnace is to be worked. Their cross-section, however, can be calculated when we know the volume of gas or air leaving the regenerators and their temperature, or the volume of the products of combustion entering the regenerators and their temperature. They should be so designed that the velocity of the gases through them is not over 20 meters per second, while 10 meters per second is a better velocity to use. A long furnace can admit of higher velocities at the ports than a short one; but in any case the higher the velocity the farther complete combustion will occur from the ports, and if the velocity is too high for the length of the furnace combustion may even be continued in the opposite regenerators and less than the maximum occur in the furnace. This is a condition to be scrupulously avoided if possible.

Problem 67.

Producer gas of the following composition:

CO	24.47 per cent	NH^3	0.19 per cent
CO^2	3.96 "	N^2	48.99 "
CH^4	0.30 "	Air	0.93 "
H^2	11.79 "	H^2O	9.29 "
H^2S	0.09 "		

is burned with 1.408 times its volume of moist air (see Problem 66). The furnace treats 50 metric tons of steel in 12 hours, using 17.5 tons of coal in the producers, from which 15 tons of carbon pass into the gas. The gas and air pass out of the regenerators at 1200°, and the products of combustion (assumed complete) pass into the opposite regenerators at 1400°. Assume a maximum velocity of the hot gas and air as 10 meters per second, as they pass through the ports.

Required.—(1) The volume of gas and air at 20° C. and 720 m.m. barometer used by the furnace per second.

(2) The areas of the gas and air ports.

(3) The velocity of the products entering the opposite ports.

Solution.—(1) The carbon in 1 cubic meter of the gas at standard conditions is

CO 0.2447
CO^2 0.0396
CH^4 0.0030

0.2873 × 0.54 = 0.1551 kg.

Gas used in 12 hours (standard conditions):

15,000 ÷ 0.1551 = 96,710 m^3
Per second = 2.24 m^3

Gas used at 20° C. and 720 m.m.:

$$2.24 \times \frac{273+20}{273} \times \frac{760}{720} = 2.53 \text{ m}^3 \text{ per second.} \quad (1)$$

Air used (standard conditions):

2.24 × 1,408 = 3.15 m^3

Air used at 20° C. and 720 m.m.:

2.53 × 1,408 = 3.56 m^3 per second. (1)

(2) The volume of gas used per minute, as it issues from the ports at 1200°, is

$$2.24 \times \frac{1200+273}{273} \times \frac{760}{720} = 12.8 \text{ m}^3$$

and of air $3.15 \times$ " $\times \frac{760}{720} = 17.9$ "

and assuming a maximum velocity for each of 10 meters per second, the areas of the ports must be:

Gas ports	1.28 m^2
Air ports	1.79 "
Sum	3.07 " (2)

(3) There is usually contraction when gases burn, the products having less volume than the gas and air used. Inspecting the equations of combustion of CO, CH^4, H^2, H^2S and NH^3 given in Problem 66, we can construct the following table of relative volumes concerned and the ensuing contraction:

	CO	CH^4	H^2	H^2S	NH^3
Volume used	1.0	1.0	1.0	1.0	1.0
Oxygen used	0.5	2.0	0.5	1.5	1.75
Gases combining	1.5	3.0	1.5	2.5	2.75
Volume of products	1.0	3.0	1.0	2.0	2.5
Contraction	0.5	0.0	0.5	0.5	0.25

Using 1 cubic meter of producer gas the contraction resulting from its combustion with an excess of air is

CO	0.2447 × 0.5 = 0.12235	m^3
CH^4	= 0.00000	"
H^2	0.1179 × 0.5 = 0.05895	"
H^2S	0.0009 × 0.5 = 0.00045	"
NH^3	0.0019 × 0.25 = 0.00050	"
Total contraction	= 0.1822	"

Since the volume of gas, plus air used, is 2.408 m^3, the volume of the products, at standard conditions, is

2.408 — 0.182 = 2.226 m^3

per cubic meter of gas used under standard conditions. The

volume of products per minute, at standard conditions, is, therefore,

$$2.226 \times 2.24 = 4.980 \text{ m}^3.$$

And at 1400 and 720 m.m. pressure:

$$4.986 \times \frac{1400 + 273}{273} \wedge \frac{760}{720} = 32.7 \text{ m}^3.$$

Since the sum of the area of gas and air ports is 2.91 m^2, the velocity of the products in these ports will be

$$32.7 \div 3.07 = 10.7 \text{ m. per second.} \qquad (3)$$

In both the calculations of the size of the ports and the velocity of the products we have assumed the tension of the gas, air or products in the ports to be the prevailing atmospheric tension. This may or may not be exactly true, because the air or gas may be under a slightly less tension, being drawn into the furnace by the stack draft. If the pressure inside the furnace, with doors closed, is greater or less than atmospheric pressure, the tension of the gases in the entrance ports will be correspondingly greater or less than the atmospheric pressure, while the tension of the products will probably always be less than atmospheric pressure, because of the stack draft. Under ordinary conditions these corrections are too small to need to be taken into consideration.

LABORATORY OF FURNACE.

The laboratory consists of the open space enclosed between the hearth, sides, ends and roof. Its dimensions vary with the intended capacity of the furnace and the ideas of the designer. If a hearth is to contain, say, 50 tons of melted steel, which weighs some 7 tons per cubic meter (425 pounds per cubic foot), there will be contained in the furnace at one time 7 cubic meters, or 260 cubic feet of steel. The deeper this lies the more slowly it will be heated or oxidized by the flame, and therefore there is a limiting depth of, say, 50 centimeters, or 20 inches, which it is not advisable to exceed, while a more shallow bath will result in faster working. Assuming a depth of 40 centimeters (16 inches), the volume divided by the depth will give the area of the bath:

$$7 \div 0.4 = 17.5 \text{ square meters}$$
$$260 \div 1.25 = 208 \text{ square feet.}$$

We can then either choose a convenient width, consistent with a practicable roof span, and derive the length, or choose a length and derive the width, or choose a certain ratio of length to width, and derive both. If the width is 3 meters the length must be 5.8; if the length is assumed 5 meters, the width is 3.5; if the ratio of length to width is 2 to 1, the length figures out 5.92 meters and the width 2.96. These dimensions are those of the bath of metal, and each should be increased by at least 1 meter to get the area of the hearth inside the walls, thus allowing 0.5 meter clear space all around the metal.

If a furnace is short it should be wide and the roof high, in order to give cross-sectional area and thus diminish the velocity of the gases over the hearth. The gases attain their maximum temperature in the laboratory, theoretically some 1700° to 1900°, and their velocity depends solely on the vertical cross-sectional area of the laboratory or body of the furnace. In Problem 67, for instance, about 5 cubic meters of products of combustion (measured at standard conditions) pass through the furnace per second. At 1800° this volume would be 38 cubic meters, and if the laboratory were 4.5 meters wide by 1.5 meters high above the level of bath, there would be 7.25 square meters of cross-section, and the velocity of the gases would be $38 \div 7.25 = 5.2$ meters per second. This would allow barely 1 second for the hot gases to pass over the bath, which would result in a low rate of heating and probable incomplete combustion, for the gas can only burn as it gets mixed with air, and it is hardly likely that 100 per cent of it would get mixed with air and consumed in 1 second. Such could only be attained by sub-division of the gas and air and very intimate mixture at the ports. Much of the economy undoubtedly attained by raising the roof of open hearth furnaces is due to the slowing-up of the gas currents in the laboratory, though it is usually ascribed to avoidance of contact of flame and bath, increased heating by radiation, etc. In the writer's opinion the raising of the roof from 1 to 2 meters, let us say, thus doubling the vertical cross-sectional area, cutting in half the velocity of the gases through the furnace, and doubling the period in which they are able to combine, and to radiate or impart heat to the furnace walls and charge—is the principal reason for the increased economy observed.

An equally important improvement is lengthening the distance between ports. There is a limit to the width of the furnace, set by the practicable arch for the roof; there is also a limit to the height of roof, set by the increasing distance of the gases from the hearth; when both these factors have reached their maximum, further efficiency of utilization of the heat of combustion can only be secured, as far as the body of the furnace is concerned, by lengthening the hearth. There is no mechanical limit, and in every case the distance between the ports and the velocity of the gases should be such that complete combustion takes place in the furnace laboratory before the products pass into the regenerators.

Problem 68.

H. H. Campbell gives in the *Transactions* of the American Institute of Mining Engineers, 1890, analyses made at the Pennsylvania Steel Co.'s works, as follows:

	Gas Burned, Entering Furnace.	*Products, Leaving Furnace.*
CO^2	5.5 per cent.	3.1 per cent.
O^2	2.3 "	0.7 "
CO	8.2 "	7.1 "
CH^4	7.3 "	0.0 "
H^2	39.8 "	11.6 "
N^2	36.9 "	77.5 "

Required.—(1) The proportion of the calorific power of the fuel developed while passing through the body of the furnace. (2) The proportion of the air necessary for complete combustion which was used.

Solution.—(1) One cubic meter of the gas contains the following weight of carbon:

$$(0.055 + 0.082 + 0.073) \times 0.54 = 0.1134 \text{ kg.}$$

One cubic meter of products contains:

$$(0.071 + 0.031) \times 0.54 = 0.0551 \text{ kg.}$$

Therefore, volume of products per 1 cubic meter of gas:

$$0.1134 \div 0.0551 = 2.06 \text{ m}^3.$$

Calorific power of 1 cubic meter of gas:

CO	$0.082 \times 3062 =$	251	Calories.
CH^4	$0.073 \times 8623 =$	629	"
H^2	$0.398 \times 2613 =$	1040	"
		1920	"

Calorific power of 2.06 cubic meters of products:

CO	$0.071 \times 3062 =$	217	Calories.
H^2	$0.116 \times 2613 =$	303	"
		520	"
	$520 \times 2.06 =$	1071	"

Heat developed in the furnace:

$$1920 - 1071 = 849 \text{ Calories}$$

Proportion of the possible heat development:

$$849 \div 1920 = 0.442 = 44.2 \text{ per cent} \qquad (1)$$

(2) The 1 cubic meter of gas needed, to burn its combustible constituents, the following amount of oxygen:

CO	0.082 × 0.5	= 0.041 m³
CH^4	0.073 × 2.0	= 0.146 "
H^2	0.398 × 0.5	= 0.199 "
	Sum	= 0.386 "
Oxygen present in gas		= 0.023 "
Oxygen needed from air		= 0.363 "
Air = 0.363 ÷ 0.208		= 1.745 "

For 2.00 m³ of products of incomplete combustion require for their combustion:

CO	0.071 × 2.00 × 0.5	= 0.0731 m³ ogygen.
H^2	0.116 × 2.00 × 0.5	= 0.1195 " "
	Sum	= 0.1926 " "
Oxygen present in the products		= 0.0070 "
Oxygen needed from the air		= 0.1856 "
Air needed to complete combustion		= 0.892 "
Total air needed for complete combustion		= 1.745 "
Air supplied in the furnace		= 0.853 "

Percentage supplied:

$$0.853 \div 1.745 = 0.489 = 48.9 \text{ per cent.} \qquad (2)$$

It is almost needless to remark that with less than half the air necessary for complete combustion supplied, a high calorific intensity of flame and a high utilization of the calorific power of the fuel are impossible. More air should have been used and the furnace made longer, so as to secure perfect combustion in the furnace, and not have over half the possible development left to take place in the regenerators or stack.

Chimney Flues and Chimney.

The gases pass into the chimney flues at from 150° to 450°. If their volume at an assumed average temperature of, say, 300° is calculated, they can be given an assumed velocity of 2 to 3 meters (5 to 10 feet) per second, and thus a suitable cross-sectional area of the chimney flues obtained. The stack will work best with a velocity of 5 meters per second, and thus its cross-sectional area may be calculated. A height of 25 to 30 meters (75 to 100 feet) is sufficient for most furnaces.

Miscellaneous.

Some other data useful in figuring up the dimensions and running conditions of modern open-hearth steel furnaces are the following, taken mostly from an article by H. D. Hess, in the *Proceedings* Engineering Club of Philadelphia, January, 1904:

Average coal consumption, in pounds per hour per ton of metal capacity of the furnace, 55 to 80.

Cubical feet of space in one pair of regenerators, per ton of metal capacity of the furnace, 30 to 75.

Cubic feet of space in one pair of regenerators per pound of coal consumed per hour, 0.5 to 1.0.

A correlation and combination of data of this sort, with details as to the actual working of the furnaces, would point the way towards a general solution, which would furnish the best conditions for every possible case, with strict consideration for all the variables involved.

[The next instalment of these calculations will discuss the thermal efficiency of regenerators and of the furnace as a whole, also special forms of open-hearth furnaces worked in special ways.]

Melting Points of Elements.

Mr. James Swinburne, the distinguished British electrical engineer, recently presented a paper on new electric incandescent lamps before the (British) Institution of Electrical Engineers. The subject was discussed in an able manner from the physicochemical standpoint as to the materials which may be considered to be available for filaments, and special attention was naturally paid to melting points. Mr. Swinburne pointed out the regrettable lack of exact data available at present for many materials.

In the discussion, Dr. J. A. Harker, of the (British) National Physical Laboratory, presented the table, reproduced below, giving the melting points of the elements in degrees C., arranged according to the periodic law. Dr. Harker has carried out extended researches on this matter.

Only within the last six years has our scale of high temperatures been at all defined, and in Dr. Harker's opinion there is still great uncertainty attached to the higher temperature measurements made by optical methods. In the work at the National Physical Laboratory they have endeavored to get a kind of "bench mark" for use in the preliminary mapping out of the really high-temperature region (above, say, 1,500° C.) by making a new determination of the melting point of platinum. Dr. Harker stated that the value found for the platinum point was 1,710° C.; *i. e.*, 70° lower than the old accepted value of Violle, depending on the determination made twenty years ago. The new lower value has been confirmed in Germany.

Some of the data on the table are taken direct from the papers of the various authors. To others corrections have been applied, when it has been possible to revise the standard points on which they depend, and others, again, are new determinations made at the National Physical Laboratory. Boron and carbon at ordinary pressures do not melt before volatilizing. In group four, titanium melts in the region of 2,500°, but zirconium is quite low, 1,300° C., cerium still lower, while for thorium, whose melting point is undoubtedly very high, no record of any determination has been found. The data in the eighth group are many of them very uncertain. Iridium, which melts above 2,000° C., gives off a great deal of vapor far below this temperature.

Dr. Harker's table, which we give below, is reprinted from the account of the discussion of Mr. Swinburne's paper in *The Electrician* (London), Jan. 18.

—	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
1	H −269		B	C	N −915	O 235	F 223		He
2	Li 180	Be under 1,000							Ne
3	Na 96	Mg 800	Al 657	Si	P 44	S 114	Cl −102		Ar
4	K 58	Ca 760	Sc	Ti 2,500	V 1,620	Cr 1,600	Mn 1,280	Fe 1,503 Co 1,500 Ni 1,427 Cu 1,084	
5	Cu 1,084	Zn 419	Ga 30	Ge 1,400	As 500	Se 250	Br 7		Kr
6	Rb 39	Sr 900	Y	Zr 1,300	Nb 1,850	Mo		Ru Pd 1,900 Rh 1,620 Ag 962	
7	Ag 962	Cd 322	In 176	Sn 224	Sb 632	Te 450	I 116		Xe
8	Cs 27	Ba 1,150	La 900	Ce 623	Di 940P 840N		Sm 1,350		
9					Er				
10			Yb		Ta 2,150	W above 1,900		Os 2,200 Ir 2,350 Pt 1,710 Au 1,064	
11	Au 1,064	Hg −39	K 290	Pb 327	Bi 269				
12		Ra		Th					

Table of Melting Points.

Charles Frederick Chandler

"A great name shall never pass away." Rich in that accumulated knowledge which we call wisdom, and especially so in that branch of knowledge which has for its purpose the improvement of the arts and industries, is Charles Frederick Chandler, who is easily the foremost authority in the United States on industrial chemistry. Gladly we yield space for a brief sketch of his career.

Chandler was born in Lancaster, Mass., on December 6, 1836, and received his early education in New Bedford. As a boy, he came under the influence of that great teacher of science—Louis Agassiz—and in time he entered the Lawrence Scientific School of Harvard, where he studied geology under Agassiz, and chemistry under Horsford. Choosing chemistry as his specialty, he went abroad, spending two years first at Göttingen, where he followed his favorite study under Wöhler, and then at Berlin, where he assisted Heinrich Rose.

C. F. Chandler

In 1856 he returned to the United States and soon was called to the chemical department of Union College, in Schenectady, where even before he attained his majority he succeeded to the duties of the full professorship. Here he remained for eight years, unfolding the fascinating wonders of chemistry to ever-increasing classes of students.

The rapid development of the natural resources of our country clearly indicated the necessity of some means for providing properly equipped experts to take charge of the many industrial works that were rapidly coming into existence for the conversion of the crude products of the soil and forest into the finished articles of commerce, and so half a century ago technical schools were created from which soon were graduated chemists, mining engineers, metallurgists, and the like. One of the first of these institutions was the science department of Columbia University, which began its life in 1864 as the School of Mines of Columbia College. The project and plan of this school originated with Thomas Egleston, a graduate of Yale and the Ecole des Mines of Paris, who took the chair of mineralogy and metallurgy. Gen. Francis L. Vinton, a graduate of West Point and the Ecole des Mines, took the chair of civil and mining engineering, and Chandler took the chair of chemistry. The school opened Nov. 15, 1864, with twenty-four students, the number increasing to forty-seven during the first session.

Full of enthusiasm at the opportunity and strong with his love for chemistry and for teaching, he organized the department and taught his chosen science and geology. He builded so wisely that to-day, forty-three years later, as Mitchill professor of chemistry in Columbia University, his name stands first at the head of twenty associates in the chemical department, most of whom studied under him, and all of whom are proud to call him master.

There was much work for him in those early days, for soon the College of Pharmacy sought and obtained his services, and the College of Physicians and Surgeons claimed a share of his time, and so he was a potent factor in the increase and diffusion of a knowledge of chemistry. And yet there is more. He became chemist to the Metropolitan Board of Health, and milk was purified, illuminating oil made non-explosive, the water supply freed from contamination, the adulteration of food checked, and other sanitary reforms made, until it seemed as if chemistry under Chandler's hands was the magic wand by which all things were made pure and healthful. His splendid work led to his appointment in 1873 to the presidency of the Board of Health, and when, in 1884, he retired from office, the statement, "There is no other city in the world which has so complete a sanitary organization as New York," was published as a parting benison in worthy recognition of his arduous labors for the benefit of humanity.

In 1870, with his brother, the late William H. Chandler, professor of chemistry in Lehigh University, he established *The American Chemist*, a monthly journal devoted to chemical science. In addition to this, he wrote a series of articles on technical chemistry—"the best in the English language"—for Johnson's Universal Cyclopedia, and the university and the students profited thereby, for it led to the forming of the only museum of raw materials and products connected with chemistry in this country.

Then there were public lectures before the American Institute, the Academy of Sciences, and other similar organizations, to which many came, for Chandler has no superior in the art of lucidly describing things technical, and always holds the attention of his audiences, whether students or jury. A word must be added of his success as an expert in court. His testimony seldom fails to carry conviction. He tells the whole truth, and the verdict is his because he is right.

His fellow workers in science have often shown their appreciation of his ability. In 1874 he was elected a member of the National Academy of Sciences, and to him that body has entrusted important governmental commissions, notably the one on the best means of preserving the writing on the Declaration of Independence. In 1874 also he presided at the centennial celebration of the discovery of oxygen held in Northumberland, Pa., where Priestly, the father of modern chemistry, lies buried. Twice he has been president of the American Chemical Society, and in 1889 he was chosen president of the English Society of Chemical Industry, being the first American to receive that honor.

His contributions to sanitary science were recognized by the honorary conferment of the degree of M.D. by the University of New York in 1873, in the same year Union, where he first taught, enrolled him among her honorary alumni by giving him her highest doctorate, that of Laws, and finally Oxford, in 1900, crowned him with the well-merited degree of Doctor of Science. His last honor came only a few months ago.

The University of Göttingen, where he received his degree of Doctor of Philosophy in 1850, sent him a new diploma in recognition of his fifty years of active work in chemistry.

Thus has his life been spent, and now, at the age of three-score-and-ten, his ever-youthful enthusiasm finds interest in new projects for the advancement of chemistry. Among these may be mentioned an ambition to secure an endowment for the Chemists Club, of New York, of sufficient size to permit the securing of a library in duplicate, so that, in addition to the series of books retained at home for reference, chemists throughout the country may borrow from the consulting department the entire literature of any subject for a definite period of time.

In the mines of South Africa, in the universities of far-away Japan, and all the way between are busy workers in science, who have learned their art from Chandler, and all of whom sincerely hope that long years of health and activity may yet be his. Marcus Benjamin.

[A few additional words may be said as to Prof. Chandler's intimate connection with the special field of electrochemistry. Dr. Chandler was one of the earliest students in America of electrochemistry. He acted as expert in the suits brought by Isaac Adams to secure his rights to the invention of nickel plating; acted as expert for Mr. Thomas A. Edison in connection with his electric soldering of lamp filaments and his famous feeder case, was expert in many of the important storage battery cases; acted for the Pittsburg Reduction Co. in defending the Hall aluminium patents, and for Mr. Acheson in defending his carborundum inventions; for the Carbide Co. in its interference case; for Hamilton Y. Castner in connection with his processes for manufacturing sodium, peroxide of sodium, cyanides, caustic soda and chlorine, and more recently acted as expert in the zinc plating litigation.—Editor.]

Bleaching Liquors.

At the Bavarian Jubilee Exhibition in Nuremberg, in 1906, an electrolytic plant for producing hypochlorites, according to the patents of Schoop, was shown in operation. It is described by A. Hundt in *Elektrotechnische Zeitschrift*, Dec. 27. Figs. 1 to 3 show the arrangement.

The electrolyzer E consists of ten shallow hard-rubber boxes, which are placed in pairs of two on a stairway of five steps. The boxes are divided by means of insulating walls into a number of channels, about 1.5 cm. broad through which a 10 per cent solution of sodium chloride is passed.

The solution passes from the distributing vessel G into the upper boxes and flows gradually downwards and from the lowest ones into the concrete tank Z. While the salt solution is run in that way through the boxes, it is electrolyzed. For this purpose the boxes are provided with electrodes which connect the different channels with each other and with the terminals for the supply current, as shown in Fig. 2.

FIG. 2.—ELECTROLYTIC BOXES.

In order to get a high concentration of bleaching liquor the electrolyte is passed several times through the boxes. The pump C lifts the solution from the tank Z back into the vessel G, from where it passes again through the boxes. At the same time, the solution is cooled artificially by means of the cooling soil *Sch.* from the cold-water reservoir W. When the electrolysis is completed, the valve V is turned and the liquor passes into the storage tank B. It is then diluted with eight or ten times its volume of water before it can be used for bleaching.

The operation is as follows: The solution of sodium chloride is prepared in the solution tank L, and is then passed into the settling tanks M N, and from there, after the spigots K and J have been opened, it is lifted with the pump C into the tank G, from whence it flows through the boxes E into a tank Z. As soon as the latter is filled, the spigot H is opened and the spigots K and J are closed and the direct-current circuit is closed.

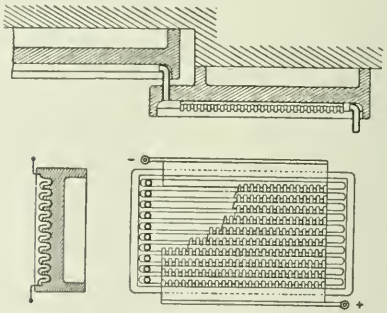


FIG. 3.—ARRANGEMENT OF ELECTRODES IN ELECTROLYZER.

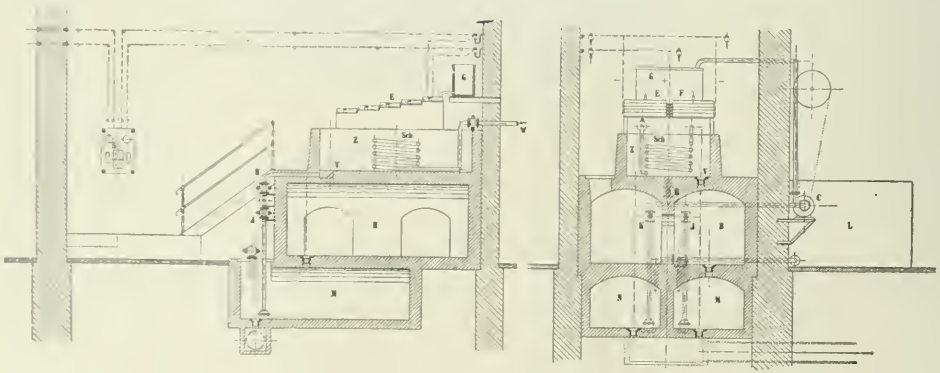


FIG. 1.—GENERAL ARRANGEMENT OF HYPOCHLORITE PLANT.

The apparatus is generally designed for 110 volts. The electrodes are either made of platinum-iridium for both poles, or platinum-iridium is used only for the anodes and graphite for the cathodes. The first arrangement, which is shown in Fig. 3, has the advantage of less consumption of

current, but is more expensive and is more sensitive with respect to variations of temperature, since the temperature of the electrolyte must be maintained constant at 15° C., while with the second and considerably less expensive arrangement, the temperature may rise to 25° C. The apparatus produces about 0.2 kg. of bleaching chlorine per kw.-hour, with a consumption of about 1.25 kg. of common salt. Electrolytic bleaching liquor can be stored for several days without losing its bleaching activity.

Nitrogen in Iron.

Hjalmar Braune furnishes us with the most exhaustive treatise on this subject yet published. His original article of over a hundred pages in the *Swedish Iron Society Journal* is condensed to some eighteen pages of *Stahl und Eisen*, in the numbers of Nov. 15, Dec. 1 and Dec. 15, last. The circumstances leading to Braune's investigations are thus narrated in the first paragraphs of his article. During the last decade of the last century, many Swedish blast furnaces sent pig iron to England which was complained of, because the wrought iron produced from it was brittle at orange heat. The analysis of this iron showed no variation from previous good-quality iron, and the cause of the trouble was a mystery. The most various theories were proposed to explain the reason for these difficulties. In 1900 and 1901, Braune commenced a systematic examination of a large number of Swedish blast furnaces, from which it was learned that the bad iron was produced whenever a certain limit of temperature was surpassed in the smelting zone of the furnace, and basic slag was produced. Under these circumstances, potassium cyanide is formed in the furnace and poor iron results; from which it was concluded that the absorption of nitrogen from this cyanide, by the pig iron, was the primary cause of the subsequent troubles. In 1903 Braune began to investigate various kinds of iron and steel in the most various ways, in order to determine whether the explanation offered was correct. The result of this research was to show that iron takes up nitrogen not only in the blast furnace, under the conditions mentioned, but also in any metallurgical process wherein nitrogen and carbon have opportunity to act on iron at a high heat and in the presence of a basic slag, and that the resultant product has its properties profoundly modified by this absorption. These researches were carried out in the University laboratory at Basel, in the Testing Bureau at Zurich, and at the College des Mines in Paris.

The first point of attack was to determine the condition in which nitrogen exists in iron. Since hydrochloric acid dissolves iron without evolving cyanogen gas, or hydrocyanic acid gas, it was concluded that the nitrogen in commercial forms of iron is not present as iron cyanide or as any cyanide compound. Experiments showed that on solution in hydrochloric or sulphuric acids, no free nitrogen is evolved but that all the nitrogen in the iron is converted into chloride or sulphate of ammonium; the conclusion is that the nitrogen is present in the iron as a nitride, probably Fe_3N_2. It is true that cyanogen or hydrocyanic acid gas is given off when iron is dissolved in nitric acid, but this does not prove that nitrogen exists in the iron as a cyanide, because perfectly pure iron carbide containing no nitrogen acts in the same way, showing the nitrogen in the cyanogen to come from the nitric acid used. Incidental to this test, Braune showed that Eggertz's carbon color test is not influenced or rendered inaccurate by the presence of nitrogen in the steel in various amounts.

Braune next prepared specimens of iron and steel with varying amounts of nitrogen, but otherwise of constant composition. The specimens were heated in a porcelain tube to 600° to 800° and dry ammonia gas passed over them. After this treatment, the nitrifaction is greatest on the outside, just like cementation or case-hardening; to render the distribution of nitrogen uniform the pieces were packed in sand in a sheet-iron case and annealed. By repeating these operations, specimens were made containing as high as 7 per cent of nitrogen, uniformly distributed. In general, the per cent of nitrogen cannot be inferred from the fracture of the material, but chilled cast iron forms an exception. In ordinary chilled pieces, the boundary between grey and white is sharp, and if blow-holes are present, they are in the white part, with rounded sides; as the nitrogen content increases, the boundary between the two colors becomes less and less distinct, white patches become common in the grey part, and *vice versa*, and small gas cavities appear in the grey part, with sharp corners. Braune could not determine any characteristic change caused by small amounts of nitrogen in the appearance of either white, grey, or puddled iron. But 0.03 to 0.045 per cent of nitrogen will cause the small gas cavities referred to in white iron, and enough nitrogen to cause bitterness will give a crystalline fracture, with bright reflections, to soft iron.

To test the mechanical properties of iron containing nitrogen, soft wrought iron containing 0.06 per cent carbon, 0.01 silicon, 0.06 manganese, 0.05 phosphorus and 0.005 sulphur was nitrated until it contained 0.015 to 0.120 per cent of nitrogen. The tensile strength is found to increase 0.035 kg. per square millimeter (50 pounds per square inch) for each 0.001 per cent increase in nitrogen, and the extension before fracture to decrease about 0.1 per cent for each 0.001 per cent of nitrogen. Specimens containing less than 0.60 nitrogen could be forged and welded easily, but with greater amounts showed brittleness, hot and cold.

Steel containing 1.15 per cent carbon, 0.20 silicon, 0.45 manganese, 0.025 phosphorus and 0.012 sulphur was next treated similarly, with surprisingly different results. The tensile strength increases slightly and elasticity decreases regularly to 0.035 per cent of nitrogen, at about the same rate as for wrought iron. Just above this point, however, the tensile strength fell off suddenly 6.2 kg. per sq. m. m. (9,000 lbs. per sq. inch), while the elasticity fell at one stroke from 16 per cent down to 2 per cent. Similar tests on best high-carbon steel and soft girder steel showed again the danger line for nitrogen to be 0.035 per cent, above which brittleness and loss of forging qualities occur. Hardening cracks in steel occur plentifully when nitrogen is above 0.02 per cent. Hardened steels are more sensitive to the effect of nitrogen than unhardened.

The electrical resistance of soft iron wire is increased by the presence of nitrogen, 0.267 per cent of nitrogen increasing the resistance 16 per cent, or lowering the conductivity 14 per cent, while the wire is made also less tough. Telephone and telegraph wires should therefore contain as little nitrogen as possible. The magnetic qualities of soft iron are also greatly altered by nitrogen, which acts similarly to carbon, decreasing the magnetic saturation capacity and increasing permanent magnetism. Sheet iron for transformers should be as low as possible in nitrogen, since the bad effects are much greater than when used as magnet cores.

The metallographic examination of iron containing nitrogen showed a change from amorphous to crystalline structure as nitrogen increased, depending on the content of carbon, intermingled slag and the working of the piece. Nitrogen causes the development of the Neuman lines, such as are seen in meteorites, which latter also contain large amounts of nitrogen. At 0.040 per cent nitrogen, where the sudden drop in extensibility occurs, a new microscopic structure occurs, consisting of a quantity of rings looking like craters, uniformly disseminated over the grains of ferrite. The rings are iron nitride and the background cementite. As nitrogen increases, these craters become more numerous, and at 0.150 per cent run into finger-shaped markings.

An investigation of many samples of commercial wrought iron and steel from all over the world showed 0.062 per cent of nitrogen as the highest and 0.02 per cent as the lowest. Grey pig iron is generally nearly free from nitrogen, coke iron of this class showing 0.007 to 0.009 per cent, but in a few

Swedish furnaces up to 0.020. White pig iron usually contains much more, especially in coke iron; in iron for Bessemer use, Braune found 0.02 to 0.03 per cent. for basic open-hearth 0.025 to 0.35 per cent. iron for puddling 0.03 to 0.035 per cent. Exception to these figures is some Swedish white iron, which runs only 0.003 to 0.020 per cent. "Washed" pig iron from different countries showed unusually high nitrogen, varying between 0.035 and 0.050 per cent, which often results in the production of crucible steels brittle because of nitrogen. Good basic steel contains usually 0.020 to 0.025 per cent of nitrogen, occasionally as much as 0.030 to 0.35. Swedish crucible steel is very low, 0.000 to 0.020 per cent at the most. Electric furnace steel made by resistance heating is practically free from nitrogen, but when made by arc heating, in presence of a basic slag, may contain much nitrogen and even injurious amounts.

Braune concludes by stating that the complete ignoring of nitrogen as a factor in commercial iron and steel is no longer possible, and that it should have a place in specifications, about, for instance, as follows:

	Nitrogen.
Beams, ship plates of wrought iron or soft steel, under	0.030 per cent
Rails of medium hard steel, under	0.025 "
Railway springs, tools of hard steel, under	0.012 "
Cannons, parts of rifles, under	0.008 "

Such specifications can be readily lived up to by the present methods of manufacture, if care is taken, particularly as to the nitrogen content of the raw material used.

Jos. W. Richards.

Faraday Society.

The twenty-fifth meeting of the Faraday Society was held on Jan. 15, Past President Sir Joseph Swan being in the chair.

Electron Theory and Electrolysis.

Mr E. E. Fournier d'Albe read a paper and opened a general discussion on "The Application of the Electron Theory to Electrolysis."

The electron theory by postulating the existence of material carriers of all electric charges, is practically an extension of the ionic theory to solids and gases, and it thus brings into line the processes of metallic and electrolytic conduction. In both cases the conductivity of a body is defined by the number of ions (in the wide sense) it contains in unit volume and by their average mobility; in a cm.-cube of copper, for example, a current is conveyed by some four hundred trillion free electrons, in a cm.-cube of milli-normal hydrochloric acid the current is conveyed by some two trillion hydrogen and chlorine ions. In a 1-mm. copper wire carrying 1 amp. the electrons will move at about 1 cm. per second.

It is not yet clearly understood why free electrons should be observed in a vacuum and a metal, but that there should be none in a liquid. It is supposed, however, that it is the close packing of the metallic atoms which renders possible a frequent exchange of electrons between one atom and another, and while free the electron is able to fall along the potential gradient and thus constitute a current. In an insulator the electrons are effectively bound up with the atoms or molecular groups; in an electrolyte mobile charged groups are formed, which can follow the e. m. f. Free electrons are not formed on account of the unequal attractions for these displayed by the positive and negative atoms of the solute. Thus in an HCl solution, when two atoms of a molecule separate, the hydrogen atom will lose an electron and become positively charged, while the chlorine atom will gain one and become negatively charged. These ions will act as condensation nuclei, gathering molecules of the solvent around them and becoming "hydrated." The expenditure of energy involved facilitates the condensation, which explains the low mobility of the ions and the variability of the same, the drop of potential at the electrodes, and the liberation of uncharged products. The e. m. f. is unable to drive the hydrated ions into the closely packed atoms of the electrodes, but if it exceeds a certain minimum it is able to drive electrons in or out, as the case may be, and the constituent elements of the ions then lose their condensing powers, drop the water molecules, and are thus liberated as uncharged atoms.

The author draws attention to the importance of making further studies of mobility and quantitative determinations of the hydration of ions as a preliminary for determining the sizes of the ions and of their actual constitutions based on kinetic principles. It is possible that the motions of heavy ions may be actually observed in an ultra-microscope. The future development of electrolytic theory will lie, in the author's opinion, in the direction of statistical analysis of these motions of the ions through the electrolyte and into the electrodes, after the fashion of Thomson's "counting experiment," and in the complete determination of the energy transformations at each stage.

Mr. John G. A. Rhodin considered that the electron theory, like the atomic theory, merely complicated matters, and was unnecessary. The conception of infinite divisibility was a necessary one in physics as in mathematics, if our reason was to be satisfied. Both in chemistry and physics we know of mathematical relations only, and hypothesis are only crude images. The ether and electrons were invented because certain phenomena could be the more easily treated mathematically by means of these conceptions. A simple theory of ions was all that was necessary for understanding electrolysis; more hypotheses were not wanted. Existing theories left many well-known facts without explanation. He suggested the appointment of an international committee for generalizing existing theories and making them available to the average intelligence.

Dr. H. Borns asked whether the Hall effect and the recent experiments of Kaufmann did not throw some doubt on the electron theory. Why were there no free electrons in liquids?

Dr. J. A. Harker was not clear as to whether the theory supposed atoms to be composed entirely of electrons or whether there were a central nucleus. If the former, one would expect more intermediate formations. He thought the fundamental conceptions of the theory should be made perfectly clear, so that the explanations of various phenomena given by it could be deduced from some simple postulates.

Dr. T. M. Lowry pointed out that much of the work on hydration asked for by the author had been carried out, among others, by Blitz, Jones and Bousfield. The latter had shown, for example, that the chlorine ion attracted five water molecules to itself.

Mr. N. T. M. Wilsmore considered that the theory, which looked upon electrons as exerting a sort of osmotic pressure at the surface of an electrode, conceived admirably the mechanism of electrode potential and of electrode reactions. It was noteworthy that the more electro-positive a metal, the more easily it threw off electrons under the stimulus of ultra-violet light, for example. He showed how the theory explained, in a simple manner, oxidation and reduction phenomena and the action on the positive accumulator plate. He thought that the negative electron should have a distinctive name, and proposed using the word "negatron," which had been suggested.

Mr. F. Kaye remarked on the simple explanation of the different mobilities and, therefore, hydrations of the various ions on the view that the positive and negative ions acted to different degrees as condensation nuclei. He asked whether when a liquid was evaporated there was a movement of electrons into the vapor.

Mr. F. S. Spiers pointed out that the theory did not seem to help in explaining the fundament preliminary to electrolysis, namely, dissociation in solution.

Mr. E. E. Fournier d'Albe replied to the various speakers.

He did not think that the few considerations put forward by Mr. Rhodin overthrew the theory. The difficulty of the Hall effect mentioned by Dr. Borns was more serious, but the negative swing that had been observed might be due to positive ions of great mobility, and not necessarily to the existence of positive electrons. A similar recent observation of the Faraday effect could be similarly explained. Kaufmann's experiments dealt with structure of electrons and merely pointed to Abraham's theory of a rigid electron being more probable than Lorentz's, which, in order to account for the Michelson-Morley experiments, supposed the electron to become shortened in its passage through the ether. Their great mobility in face of little resistance would prevent free electrons existing in liquids. When a metal was liquified, probably polymerization took place, and ions were formed which carried the current.

In reply to Dr. Harker, it seemed that atoms most likely consisted of negative electrons whirling round a positive nucleus. The solar system presented a close analogy. Only certain configurations would be stable, hence every intermediate stage of element would not persist. The theory at present could not be built up from simple postulates; it was in the induction stage, and kept in close contact with facts.

In reply to Mr. Kaye, electrons did not pass into the vapor from a boiling liquid; the surface of the liquid was a perfect semi-permeable membrane.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

Hypochlorites and the Safeguarding of Water Supplies.

Close upon the first meeting of the Faraday Society (to which I referred in my last letter as notable as being given up to hypochlorites), there followed a meeting of the Society of Engineers in which the atmosphere was similarly chlorous. The paper, which was by Mr. W. Pollard Digby and Mr. C. H. Shenton, was entitled "The Bacterial Contamination of Streams and Oyster Beds." It may be divided into four sections: (a) the need of sterilization as advanced by the reports of various Royal Commissions, (b) means of sterilization, chlorine in the form of hypochlorite being recommended, (c) a history of the application of hypochlorite processes, with notes on various patents, and theories as to the reactions taking place during electrolysis, (d) and the cost of application and its relative apportionment between the sewage and other authorities.

A 90 minutes' discussion followed, mainly of a bacteriological nature. On the electrochemical side, various speakers (Mr. C. V. Biggs, Mr. E. F. Pollard, Mr. E. C. Thrupp and Dr. F. W. Alexander), dealt with such points as stability, and the substitution of graphite for platinum in the construction of the anodes.

It may perhaps be mentioned that this paper gives the first public description of the new Digby electrolizer. The particular feature of this apparatus consists in the manner in which the re-combination of the anode and cathode products is secured. In place of the re-combination taking place in the main body of the electrolyte, it can only take place in the special porous compartment closely enclosing the electrodes. The re-combination may take place in either the anode or in the cathode compartment, the products of the one compartment being conveyed to the other compartment. Thus the caustic hydrate from the cathode cell flows by gravity into the anode compartment, the two compartments being connected by a glass pipe. Fresh water, or water containing an excess of alkali, is run into the cathode cell. This process gives hypochlorite solutions of low saline content, the only salt present in the resultant liquor being that due to diffusion depending upon the porosity of the closely covering compartment walls.

As to the ultimate reaction between the sodium hydrate formed at the cathode, the authors referred to that given in Mr. J. B. C. Kershaw's recent article in Electrochemical and Metallurgical Industry, and quoted one more generally accepted, and given by Mr. Bertram Blount in his "Practical Chemistry,"

$$2NaOH + 2Cl = NaOCl + NaCl + H_2O.$$

This explanation accords with that favored by Professor Ostwald, in Part 2 of his "Conversations on Chemistry," in describing the formation of sodium hypochlorite by chemical means.

They also offered for consideration the view for a long time privately held, and now publicly advanced for the first time, by Mr. W. Pollard Digby, that for low strengths the reaction is

$$NaOH + Cl = NaOCl + H.$$

The reasons for favoring this most simple hypothesis are two-fold, being, firstly, the large number of authenticated cases in which the electrochemical efficiency of production has not been 50 per cent or under, as would agree with either the Kershaw or Blount hypothesis, but upwards of 80 and 90 per cent, which would agree more clearly with the simplest hypothesis described; and, secondly, the fact that when the recombination does take place under special control, there is a gaseous evolution on the mixture of the anodic and cathodic products. The character of this gaseous evolution has not (up to the time of writing) been determined, but attention is being given to the matter. For high strength solutions, and in cases where the current efficiency is 50 per cent or less, the Blount and Ostwald explanation should be accepted. It seems, however, scarcely tenable where it can be proved that the current efficiency is 70 per cent or higher.

Presidential Addresses and Electrochemistry.

It has been my custom on two previous occasions to use the above heading as an introduction to my notes on any subject matter of an electrochemical or electrometallurgical nature in the presidential addresses delivered to the various engineering and scientific societies in London or in the provinces. I have heard several such addresses, and read more. But, in striking contrast with previous years, I find an utter dearth of reference. Even the high price has not led any president of the institution of Electrical Engineers to allude to the value of aluminium, and the manner in which the British Aluminium Co. are pushing ahead with their Loch Leven scheme.

One note is frequently reiterated, and that is the valuable services rendered to the metallurgical industries by the simplicities ordained by the Engineering Standards Committee. Another matter frequently referred to was the advent of the metallic filament glow lamp. Nothing new was said upon either subject.

I must, however, mention Dr. Charles Drysdale's address to the students of the I. E. E. upon the "Electrical Industry at Home and Abroad." Not for its direct electrochemical or its electrometallurgical interest, but for its plea for the wider culture, which is so often lost sight of in our colleges. Dr. Drysdale's advice was, "Study ethics, economics and hygiene. Remember that you are a human being first, and an engineer afterwards. The works of Adam Smith, Ricardo, Bentham, Bain, Malthus, J. S. Mill and William Ellis are mines of almost unexplored wealth, and should enable you to avoid very many pit-falls. After you may have read these you may try Henry George and Karl Marx, in order to know what labor is being fed on. Had I my way, a course on these subjects, as well as in commercial matters, should be an essential feature of every engineering college training, even at the cost of leaving some technical work out * * * * There are two ways of attempting to raise oneself above one's fellow creatures. One is by pulling yourself up, the other by pushing them down."

Surely it was pure inadvertence that the works of Herbert

Spencer were omitted from this index of commended literature.

The Metallurgist and Electrical Progress.

Mr. Hadfield's speech at the annual dinner of the Institution of Electrical Engineers paid tribute to the good work done at the National Physical Laboratory, and passed on to deal with the intimate relations between further electric progress and metallurgy. The metallurgist could offer a special steel with a lower hysteresis constant than pure iron, or a special steel with twelve times the resistance of ordinary iron. It was never safe to prophesy, but it was not inconceivable that some day the metallurgist might give them an alloy of iron comparable with copper in its conductivity.

The Faraday Society Meeting.

It is a great pity that the attendance at the meetings of scientific societies is not always commensurate with the intrinsic value of the papers discussed. For instance, Dr. Cumming's two papers (abstracted on page 8 of our January issue) did not receive the adequate discussion which they really merited. The paper first read dealt with "Studies in Strong Electrolytes." The discussion was opened by Mr. Wilsmore, who pointed out Planck's hypothesis necessitated ions of some valency. Dr. Cumming's work had eliminated these, and thus permitted the measurement of two electrode voltages. Dr. Lowry, who presided, referred to the curves on page 4, and asked how the true value had been obtained. As regards John's work, Dr. Lowry pointed out that concentration was not a measure of conductivity for solution of 1/100-normal, which was from the point of view of the electrolytic dissociation comparatively concentrated. In reply Dr. Cumming mentioned that the true value curve had been obtained by calculation, and that his own conclusions were that conductivity varied with the concentration up to one-half normal.

Dr Cumming then read his paper on the "Electrochemistry of Lead," which had been presented at the November meeting. The discussion was opened by Dr. Hutton, who said that the Society was to be congratulated upon receiving such papers as those by Dr Cumming. Far too many pieces of good research work were buried in the German papers, and merited a wider publicity than they received. Mr. Wilsmore thought that this paper would be of value in accumulator work, and permit the re-calculations of Dolezalek formulæ in terms of the tetrad lead ions instead of the $Pb\,O_2$ ions. Mr. H. L. Joly remarked that oxygen was tetravalent in certain organic compounds. Dr Lowry, in proposing a vote of thanks to the author for his two papers, thought that the latter might help in the elucidation of many accumulator mysteries.

This reference paved the way to the third paper of the evening, by Mr. R. W. Vicarey, on "Storage Batteries and Their Electrolytes," (also abstracted on page 8 of our January issue,) which, in the author's absence was read in abstract by Mr. Spiers. Mr. Joly then made a scathing attack on the paper, declaring that any paper submitted for discussion to a scientific Society should be the crystallized embodiment of careful experiment and sound theory. Mr. Joly declared that the present paper contained neither, and took paragraph by paragraph. For instance, the author had talked of uniformity, yet if standard dimensions, weight, discharge rate and number of plates were taken into consideration, prices would be found to vary from 6½d. to 1s. 2d. per pound. As regards ammonia, he had never found such quantities as had been mentioned. The author had for a long time been declaiming that ammonia would have to be thoroughly investigated. Then, why for goodness sake, didn't he investigate it and give them some figures? Mr. Vicarey claimed to have discovered what he called a hemi-basic sulphate crystal. The speaker begged to have samples for microscopic investigation. In short, they had had two papers from Mr. Vicarey, and were "no forrarder." Dr. Cummings criticized the author's use of platinum electrodes. A minute trace of platinum was enough to ruin any accumulator. As to the evil effect of ammonia his (Dr. Cumming's) own practice had been to wash defective plates in ammonium acetate solution. Mr. W. R. Cooper hazarded the suggestion that the paper was perhaps written or compiled in a hurry. In any case the comparative figures on the second page only gave the figures in 1902. This table would have been more explicable if it had been up to date. Other tables were quite inexplicable—the gas liberated got greater as the current got less. Mr. Cooper also wanted to know more about the new sulphate of lead. The proceedings terminated with a vote of thanks to the author on account of the discussion which his paper had engendered.

Electric Power and the Metallurgical Industries of the Rand.

To the amazement of electrical engineers in London, the preference shares to the value of £650,000, in the Victoria Falls power scheme, offered for subscription, are reported to have been fully subscribed. This ornate and grandiose scheme has been severely criticized by competent authorities, such as Sir Alexander Kennedy and Mr. Robert Hammond, who hold the view that power distribution from falls nearly 700 miles away, even if transmitted at 120,000 volts and 12½ cycles per second, cannot possibly compete with a large steam-driven station *in situ*. As a matter of fact, the promoters do not seem to display anything approaching firm faith in the long-distance transmission side of the venture. They have acquired the existing steam-driven generating plant at Vereeniging, and their prospectus contemplated a reserve steam-driven station at the Rand as well as a large hydraulic reserve station.

Electric power is invaluable in mining operations and a really cheap supply will be a boon in view of the present conditions in the Transvaal. If the long-distance transmission scheme ever becomes anything more than a project, the inevitable demand for copper to which it will give rise will be an important "bull' point for copper dealers.

Assay of Gold.

The monthly meeting of the Institution of Mining and Metallurgy, held on the 13th of December, had only two new papers submitted for consideration. The first paper, by Mr. Arthur C. Claudet, dealt with "The Assay of Gold Bars as Conducted in the Author's Assay Office," and described the carefully elaborated routine followed from the preparation of the assay piece by flattening on an anvil, through the process of weighing (which is done in two stages on rough and fine balances), their cupellation in Fletcher's gas muffle furnaces, down to the parting of the silver from the gold and the weighing of the cornets. The author also described his method of refining gold for proofs or checks, in which 12 ounces of proof cornets are dissolved in nitro-hydrochloric acid in two flasks, then thrown into two porcelain dishes and evaporated until chlorine commences to be given off. The liquor is then taken up with distilled water, thrown into a large glass jar (25 inches high and 13½ inches diameter), and diluted quarter full. It is allowed to settle for three weeks at least, then syphoned off through a filter into a similar sized jar; 2½ pounds of pure oxalic acid, dissolved in water and filtered, are added and well stirred; a cover is put on the top of the jar, and it is allowed to stand two or three weeks, after which the liquor is syphoned off. The gold is collected in a porcelain dish and thoroughly washed by decantation with boiling distilled water, then with hydrochloric acid, re-washed with water, then washed with several fresh quantities of ammonia and water. Finally the gold is collected and dried, then placed in a clay fluxing pot and melted with a little nitre. The button, after breaking the pot, is washed with water and hydrochloric acid, re-melted in a plumbago pot and cast into a small, very clean mould; the bar is re-washed and got as clean as possible. Then it is rolled in rolling mills specially cleaned for the purpose, into a strip, which is thoroughly cleansed before use. Pieces of the gold thus obtained are

assayed before use by Johnson & Sons, and Johnson, Matthey & Co., and are invariably reported as 0.99995 to 1.00000.

The second paper, by Mr. G. F. Heath, described "The Water Race for the Chuquitambo Gold Mines, Peru," and is an interesting account of practical civil engineering construction. It does not, however, call for further description in these notes.

MARKET PRICES DURING DECEMBER.

The last day of the year naturally affords, not only an opportunity for speaking of prices during the preceding month, but, also, of saying a few words upon the year's records generally. Regarding the month, however, first, one has again to record a state of affairs in regard to the metallurgical industries wholly favorable to the producers of the raw material, but of high prices to the consumer.

Copper, which touched £108 per ton before Christmas, eased slightly owing to Christmas and New Year holidays, and closed at £105.5. Tin has been subject to relatively slight fluctuations, closing rather easier at £193.12.6, the holidays again tending to depress prices. The activity in the heavy engineering trades maintained pig iron at prices of over 60s. per cwt. for Cleveland warrants closing at 62s. on Dec. 31. Lead has remained firm, closing at £19.17.6 per ton. The chief prices to be noted in regard to chemicals are sulphate of ammonia £12.5 per ton, bleaching powder (35 per cent) £4.12.6 per ton, copper sulphate £32 per ton, cyanide (98 per cent minimum) 8½d. per pound, potassium carbonate (90-92 per cent) £18.15 per ton, caustic soda, white (77 per cent) £10.12.6 per ton, zinc sulphate £8.10 per ton. Shellac £9.11 per cwt.

Of advances during the year, Cleveland iron has risen 9s. per cwt., lead has risen £2.13 per ton, copper £25,10 per ton, and tin £32.7.6. Twelve months ago I remarked that the general outlook in the engineering and allied trades looked very favorable. Now we are in full swing, with many works booked up with orders for several months. Late deliveries of steel, both rolled and cast, are giving a good deal of trouble. Continued activity seems probable, the only disturbing element being the fear of bad harvests abroad, which would restrict the purchasing powers of certain large non-manufacturing countries.

LONDON, Jan. 5, 1907.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

ELECTRIC FURNACE.

Crucible for Induction Furnace.—E. A. Colby, 840,825 and 840,826, Jan. 8. Application filed Nov. 23, 1905.

These two patents refer to the mechanical construction of the annular crucible containing the molten charge in an electric induction furnace. The cross-section of the design of patent 840,825 is shown in Fig. 1. B is the chamber containing the molten charge, while A is a recess, which may be filled with heat-insulating material, like magnesia or asbestos, or may be left empty to reduce loss of heat by condensation; or the primary inducing coil may be placed in it. Patent 840,826 refers to the construction of the annular crucible of a number of arc-shaped sections, fitted together by keyways and keys in dovetail shape.

FIG. 1.—CRUCIBLE.

Fused-Quartz Receptacle for Electric Furnace.—Wm. H. Bristol, 839,983, Jan. 1. Application filed Aug. 6, 1901.

Within heat-insulating walls of fire-clay or magnesia, etc., a crucible is placed of fused quartz, around which the heating wire of platinum is wound. The advantage of using a fused quartz crucible is that fused quartz has practically a zero or negligible coefficient of expansion with heat. A fused quartz crucible may be heated red-hot and will not crack if water is poured into it. For this reason, if the furnace is to be used, the full current may be turned on immediately without any use of rheostats, etc., and without any danger of the quartz crucible cracking. A great saving of time thus results in the use of the furnace. A crucible furnace of this type is shown in Fig. 2, in which 14 are the refractory walls of fire-clay or magnesia, etc., 13 a layer of asbestos, 11 the heating platinum resister and 10 the furnace quartz crucible. To generate sufficient heat in the platinum resistor the inventor makes it of flattened form, and winds it edgewise with respect to the receptacle, as indicated in the illustration.

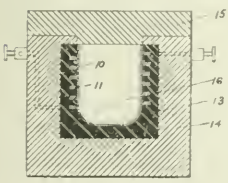


FIG. 2.—ELECTRIC FURNACES.

Carbon for Electrical Resistances.—E. G. Rivers, 841,572, Jan. 15. Application filed Dec. 22, 1905.

The object is to prepare carbon "for use in the formation of electrical resistances and heater elements and as a paste for mounting and jointing electrical conductors for joining up platinum wires with carbon filaments in the manufacture of incandescent electric lamps and for analogous uses." Finely powdered retort carbon is made into a solid body of high resistance by first forming it into a paste with a solution of soluble silica or water-glass, and then subjecting the mixture to a high temperature, and also, in cases where extreme hardness is required, to the subsequent action of a solution of carbonic acid or other weak acid which will act upon and decompose the silicate.

Electric Melting or Reducing Furnace.—Gilbert C. Landis, 842,0909, Jan. 22. Application filed Sept. 21, 1904. Assigned to American Phosphorous Co.

The metallic casing B (Fig. 3) contains a lining A of vitrified bricks united by a non-absorbent mortar (*i. e.*, one composed of silicate of soda and powdered asbestos). The blocks are ventilated to prevent the absorption and loss of fumes and gases from the furnace. Then follows a lining E, composed of blocks of carbon, and this lining E is composed of an

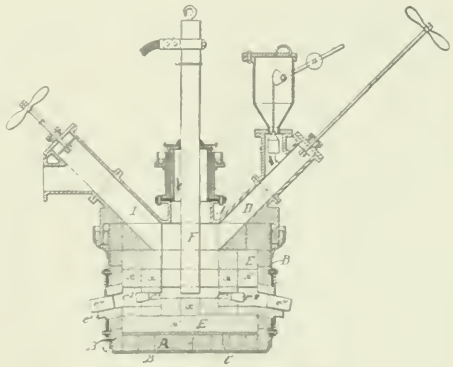


FIG. 3.—PHOSPHORUS FURNACE.

inner set of blocks x and an outer set of blocks x^1, so that when on the operating side of the furnace the inner blocks become worn away they can be replaced without disturbing the outer blocks x^1. The carbon lining E rests upon a base plate C of conducting material, from which connection is made to the outside, forming one terminal. The other terminal is applied to the vertical adjustable carbon electrode F, which is fitted in the vertical neck J of the cap plate G. There are also two inclined necks on the two sides, one H, for charging with the aid of a hopper, the other, I, being the exit of the fumes and gases. These fumes and gases are the desired product of the furnace reaction. The molten slag is tapped off through inner tapping holes e^1 (with plugs e^3) and outer tapping spouts e^2 (with plugs e^4). By providing inner and outer tapping openings the inventor is "enabled to use a plug e^2 of wood for the inner opening without luting, as it is difficult of access," while the outer opening is closed "by the plug e^4, which is luted, preventing air reaching the inner wooden plug." The furnace is continuous in its operation. Since the tapping openings are, by reason of the friction of the flowing slag, worn away more rapidly than the blocks of the inner carbon lining x, two sets of tap openings are provided, in order to use the second one after the first is worn out.

Electric Furnace.—Leon Dion, 840,481, Jan. 8. Application filed April 30, 1906. Assigned to Americus Electro-Hermetic Co.

A stack furnace is provided with two sets of electrodes passing through opposite walls, so that the ends of the opposite electrodes are near together. In this way on either side of the furnace a number of electrodes (preferably in form of plates) are mounted one above the other. From a hopper at the top the raw material drops down through the space between the two opposite sets of electrodes and is fused, and the product is collected in a crucible at the bottom.

Electric Resistance Furnace. Clarence L. Collens, 2d, 840,044, Jan. 1, 1907. Application filed Dec. 1, 1905.

The object of an improved design of a resistance furnace must be to increase "the surface of productive heat diffusion" without increasing "the surface of non-productive heat diffusion." (Concerning the definition of these terms see the inventor's paper, our Vol. IV., p. 212). Under this condition the time required to manufacture a given volume is reduced and the waste of energy is diminished. To accomplish this, the design shown in Fig. 4 is employed. The materials to be treated are ground and molded into blocks P of a predetermined size, using some such bond as pitch, tar or glue water.

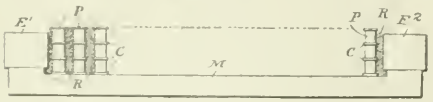


FIG. 4.—ELECTRIC RESISTANCE FURNACE.

These blocks are then placed in the furnace in tiers, the bed of the furnace between the terminals E^1 and E^2 having been first filled with some good refractory material M, which is a poor conductor of heat and electricity. Thin slabs C of graphite or carbon (or even metal, if the temperature of the reaction is low) are placed between the blocks P. The spaces between the tiers are filled with the resistance material R. The outer side walls of the furnace are then built up and the space between these and the tiers is then completely filled in with the refractory material M. The electric current passes from terminal E^1 to the first layer of resistance material R, then through slabs C to the next layer of resistance material R, and so on. The chief advantage of this design is stated as follows: "By making the blocks P of one-half the width and the zones of heating of one-half the thickness the surface of productive heat diffusion can be practically doubled without increasing the total volume of the resistors or the area of the surface of non-productive heat diffusion. By still further subdivision within certain practical limits any degree of distribution of the heat generated throughout the mass under treatment can be obtained, each sub-division resulting in an increase of thermal efficiency without a corresponding proportionate increase in the labor costs or a decrease in the ease of construction and operation." Another advantage is that "if the slabs C possess higher electrical conductivity than the material under treatment the latter is practically short circuited by these slabs, and hence any change in the conductivity of the blocks P during the run does not materially alter the resistance of the furnace as a whole. The voltage regulation therefore does not require a wide range, and the source of electrical supply is a simpler less expensive style of apparatus than with some other types of incandescent furnaces."

Electrolytic Processes.

Electrolyte for Production of Alkali Metals.—G. O. Seward and F. von Kugelgen, 841,724, Jan. 22. Application filed April 23, 1906.

In the electrolytic production of the alkali metals from their chlorides it is necessary to employ an electrolyte of low melting point, for the reason that the output of metal decreases as the temperature of the bath increases. The new electrolyte of the inventors consists of the chloride of the alkali metal sought, a fluoride of the same metal, and a chloride of an earth-alkali metal, for instance, a mixture of four parts NaCl, two parts NaF and one part $BaCl_2$. This mixture remains fluid below a red heat. For the production of potassium a mixture of KCl, KF and $BaCl_2$ is used. Besides their low melting point these electrolytes have the advantage that there is no danger of contaminating the alkali metal sought by another alkali metal, "since the earth-alkali salt is not decomposed at the current density used in the production of the alkali metal."

Lead and Zinc from Sulphide Ores.—C. E. Baker and A. W. Burwell, 841,102, Jan. 15. Application filed July 5, 1904.

Dry ore, containing the sulphides of lead or zinc, is finely pulverized and brought into contact with vapor of sulphur chloride S_2Cl_2 in a revolving drum. Heat is applied to hasten the reaction, which is represented by the equation $MS + S_2Cl_2 = MCl_2 + 3S$, where M is a metal, like lead or zinc, whose chloride is fusible. The sulphur is recovered and the fused lead or zinc chloride is electrolyzed with graphite anodes and molten lead or zinc cathodes. The chlorine set free at the anode may be used for producing sulphur chloride, which is employed again in the continuation of the process.

Copper from Sulphide Ores.—C. E. Baker and A. W. Burwell, 841,103, Jan. 15. Application filed March 1, 1905.

Copper sulphide is first treated like lead and zinc sulphides in the preceding patent. The reaction with sulphur chloride yields sulphur and cuprous chloride which is leached out and electrolyzed.

Copper, Nickel, Cobalt from Ores.—John H. Ryan, 841,720 and 841,721, Jan. 22. Application filed March 1, 1906.

The object is the treatment of ores containing copper or nickel or cobalt or all of these metals in combination with sulphur or arsenic. The finely-ground ore is first subjected to a roasting operation in a number of successive stages at gradually increasing temperatures. The inventor prefers a McDougall furnace with a pyrometer in each shelf, a constant temperature being maintained on each shelf, but the temperature increasing from shelf to shelf downwards. On each shelf the ore is rabbled under constant temperature conditions, maintained by manipulation of hot and cold air inlets for a definite time before being transferred to the next shelf below, where the treatment is continued at a suitable higher temperature. The following figures are given as to the successive stages: Roasting for 1 hour at 300° F., then for 1 hour at 450° F., then for 1 hour at 800° F., finally for 1 hour at 1,000° F. The ore is then discharged while still hot into a suitably dilute solution

of sulphuric or sulphurous acid for the preparation of a sulphate or sulphite solution. (The acid solution is preferably prepared from the gases derived from the roasting in well-known manner.) In the case of ores containing nickel or cobalt it is advantageous to add to the ores before conveying them to the roasting furnace about 2 or 3 per cent of sodium chloride. The initial temperature of the leaching solutions should be not less than 150° F., and where electrolytic deposition of the metals is employed the deposition should be effected at a temtemperature not below 80° F. After the metals (copper, nickel, cobalt) yielding soluble sulphates or sulphites are extracted the tailings are treated for the recovery of precious metals. For this purpose they are neutralized by lime or by the hydroxide or carbonate of sodium or potassium, and are then subjected to the solvent action of a cyanide solution and the gold and silver are recovered in the usual manner. When treating cobalt ores containing gold and silver, it is advantageous to regrind the tailings wet. The leaching operation must be varied somewhat in accordance with the character of the ore. For copper ores the copper is electro-deposited in a continuous depositing tank. In case iron is present in the ores it passes into the solution, the iron salts being oxidized in the region of the insoluble anodes. Such salts when returned to the leaching vat become effective solvents for the compounds of copper. When both copper and nickel are present the copper is precipitated as sulphide and the nickel separated by electrolysis with insoluble anodes, the copper sulphide being either redissolved and the metal electro-deposited or else reduced to metal, cast into anodes and electrolytically refined.

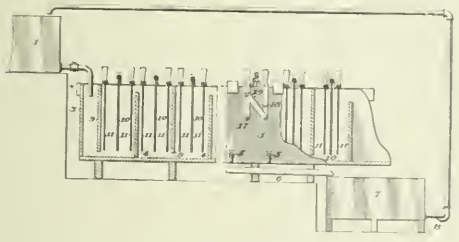


FIG. 5.—ELECTROLYTIC TANK.

In case nickel and cobalt are present together in solution, an alkali hydroxide is added in quantity just sufficient for the precipitation of the nickel, thereafter the cobalt is electro-deposited from the clear solution. The nickel may be recovered in any suitable manner, as by solution of the hydroxide and electro-deposition of the metal or by conversion of the same into metal anodes suitable for electrolytic refining.

The tank for the electrolytic metal deposition (patent 841,720) is shown in Fig. 5, where 1 is the leaching tank and 3 the electro-depositing tank. The latter is divided by the partitions 4 and 9 into a series of compartments so as to force the electrolyte to pass through the tank in a zigzag course. By means of the draw-off cocks 5 the contents of the different compartments may be discharged into a launder 6, leading to the sump 7, from where the solution is pumped back into the leaching tank. The cathodes 10 are thin sheets of the metal to be deposited. The insoluble anodes 11 may be of lead. Since the electrolyte becomes gradually impoverished during its passage through the tank, the anodes and cathodes are placed nearer together at the outlet end of the tank than at the inlet end.

Treatment of Sulphide Ores.—R. S. Packard, 840,511. Jan. 8. Application filed Jan. 11, 1906.

The object is to convert copper or zinc sulphides into sulphates by means of chlorine set free from an acid solution containing the pulverized unroasted ore. A strong solution of hydrochloric acid or a strong brine solution, kept acid by hydrochloric or sulphuric acid, is used as electrolyte. The theory of the inventor is that chlorine set free at the anode reacts with the water, forming hydrochloric acid and oxygen, which "oxygen being liberated in the nascent state in immediate contact with the sulphide particles oxidizes energetically" the sulphides to sulphates. Fig. 6 shows the construction of the tank. It has a removable false bottom, so arranged that the anodes and cathodes pass through it and reach to the bottom of the tank. The anodes are carbon rods, the cathodes

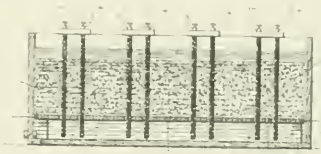


FIG. 6.—TREATMENT OF SULPHIDES.

either carbon rods or copper or iron sheets enveloped in linen clothes to retain the copper which is precipitated loosely upon them. After the copper has been leached out of the ore, the solution is tapped off into a precipitating tank containing scrap iron, upon which the copper is precipitated in form of sponge or cement copper. "If the copper ore contains gold, the action of the current should be stopped long enough before tapping to insure the complete chloridizing and solution of the gold, some of which may have been precipitated at the cathode by the reducing action of the ferrous salt formed there. The chlorine will convert the ferrous into a ferric salt and dissolve the gold. The gold may be precipitated by the addition of ferrous sulphate to the solution in a separate tank previous to the precipitation of the copper."

Water Purifying Apparatus.—A. E. Dieterich, 838,390, Dec. 11, 1906. Application filed Oct. 11, 1906.

A cylinder contains a core of non-conducting waterproof material, upon the outside of which a spiral groove is formed extending from end to end. The water enters the cylinder at one end and passes through the groove, where it is subjected to electrolytic action by means of two aluminium strips, so as to "precipitate the impurities in the water." When the water reaches the other end of the groove it enters the lower end of the interior of the hollow core, which is filled with filtering stone where the impurities are deposited. The purified water then leaves at the other end.

Water Purification.—Jacob A. Hyle, 840,335, Jan. 1. Application filed April 3, 1906.

The inventor claims (claim 5): "In an electric water-purifying and filtering system, a reservoir having a concaved bottom, a cleaning pipe attached to the bottom of the reservoir and provided with a valve, outlet pipes leading from the reservoir, filter connected to said pipes, a service pipe leading from the bottom of the filters, and an inlet pipe having a contracted discharge end and containing an electrolytic cell composed of longitudinally-extending pipes, end discs and a corrugated cell plate surrounding the pipes, and electric connections for the plate and discs respectively."

STORAGE BATTERIES.

Battery Plate.—F. C. Hood, 837,567, Dec. 4, 1906. Application filed Feb. 20, 1906.

The plate is composed of a continuous series of superimposed loops of finely corrugated lead tape. The loops are formed by laying the tape back and forth on a horizontal surface, leaving a relatively wide space between the sides of each loop. Separate strips of more deeply corrugated lead tape are interposed between the arms of each loop. This network is held together by vertical and horizontal lead bars.

Connector for Batteries.—A. F. Clark, 837,897, Dec. 4, 1906. Application filed May 12, 1903.

Details of mechanical construction of connections for bridging the terminals of successive battery cells.

Coating Active Material with Flake-Like Conducting Material.—T. A. Edison, 839,371, Dec 25, 1906. Application filed March 30, 1905.

The object is to coat electrolytically-active nickel hydroxide or other active salt with flake-like conducting material, such as flake graphite or flake nickel or cobalt, etc. (for the purpose of increasing the conductivity of the active masses in the Edison battery). Nickel hydroxide is ground and mixed with molasses. Flake graphite is added and the mixing is continued. Two parts by weight of flake-graphite are applied to eight parts of nickel hydroxide. The mass is dried and filled under light pressure into the pockets of the battery grid, which are then immersed in slightly alkaline water to dissolve the molasses. The pressure is then increased to its normal value.

Plante Plate.—Jang Landsing, 839,600, Dec. 25, 1906. Application filed Nov. 24, 1905. Assigned to General Storage Battery Co.

The object is to prevent buckling of a Planté plate, due to the thickening and elongating of the lead strips during the process of formation. The plate is made up of a frame provided with ribs. Within this frame and ribs, panels or elementary grills of lead are provided. Each panel consists of several series of vertical lead strips (which are to become active). At top and bottom these strips are provided with flexible cross supports. Recesses are cut into the outer surfaces of these cross supports in order to permit longitudinal elongation of the grill, while holes are formed in the two ribs at the side of the grill to permit sidewise elongation.

Plante Plate.—Joseph Bijur, 839,711, Dec. 25, 1906. Application filed Aug. 15, 1906. Assigned to General Storage Battery Co.

The object is to avoid straining or deformation of Planté plates. How this is accomplished is well indicated by the sixth claim, which is for a "Planté battery plate comprising frames having sides and ends and transverse and longitudinal cross-ribs provided with apertures at their intersections, active unit elements in the form of grills comprising strips connected to diagonal or cross supports, projections or trunnions at the centers of said grills, said trunnions being adapted to co-operate with the apertures at the intersections of the cross-ribs on the frames for supporting the grills centrally between the frames, said grills being supported without touching each other and without touching the frames except at their central portions, and means for centering said grills upon the frames." In one construction of grill shown and stated to be satisfactory, four sets of parallel strips are connected to diagonal supports, thereby dividing the plate into segments or quarters of pyramidal form.

Battery Connection.—Joseph Bijur, 839,712, Dec. 25, 1906. Application filed Oct. 17, 1906.

Mechanical details of construction of the connection between the plates and the strap connecting the plates together.

Primary Batteries.

Dry Cell.—John W. Brown, 838,165, Dec. 11, 1906. Application filed June 4, 1900. Assigned to National Carbon Co.

The object is to prevent the deterioration of dry cells. For this purpose the entire filling of the zinc cup of the dry cell is wrapped up in paraffin paper, which not only prevents vaporization of moisture, but insulates the zinc cup electrically from the filling. In this condition the cell is absolutely inert. When it is to be used, the inner package is taken out of the zinc cup, the paraffin paper is removed and the package is placed back into the cup.

Primary Cell.—Benj. J. Blameuser, 838,372, Dec. 11, 1906. Application filed June 7, 1905.

The object is to maintain constant concentration and composition of the electrolytes in a double-fluid cell, like the bichromate battery. During operation the sulphuric acid becomes zinc sulphate and gets thereby heavier, while the bichromate solution is reduced and becomes lighter. This change of specific gravity is made use of for automatic circulation of the liquids between the two compartments of the cell and two reservoirs containing fresh electrolytes.

Porous Diaphragm.—Frank A. Decker, 839,816, Jan. 1, 1907. Application filed March 9, 1905.

"In the electrochemical diffusion of fluids through porous diaphragms the rate of diffusion at different elevations varies with the depth or fluid pressure and results in a gradually increasing exhaustion of the fluid from the surface downward." To counteract this effect, the inventor constructs a porous cup in the form of a truncated wedge, composed of two diaphragms, with wide base flanges, sealed together to form a wide bottom, and gradually decreasing end flanges which are sealed together to form the ends of a container having a comparatively small cross-sectional area at the top, gradually increasing toward the bottom.

Coupling for Battery Elements.—Frank A. Decker, 839,817, Jan. 1, 1907. Application filed Jan. 22, 1906.

The third claim is for "a battery-electrode holder having a tapered socket and a slit therein, an envelope and a conductor to which said holder is engaged, and an electrode having an ear thereon which fits said socket, and has its connection with said electrode disposed in said slot." (Concerning the Decker cell see our Vol. IV., p. 441.)

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

Electrochemical Engineering.

Electric Steel.—In our last issue, page 25, we gave a brief abstract of the recent paper of Prof. Eichhoff on the working of the Heroult process in the plant of Richard Lindenberg, in Remscheid. Since in our columns the first authoritative information was given out concerning the Héroult process, and since we have paid continually close attention to all its developments, a great deal of the contents of Prof. Eichoff's paper is no news to our readers. Nevertheless, some points of the chemistry of the process are brought out in an interesting way, and it is also interesting to note that the *Iron Age* of Jan. 31 gives considerable space to the subject. Concerning the possibility of the electric furnace competing with the open-hearth and Bessemer processes, the author points out that at present success seems promising only where cheap power is available. In 5-ton furnaces the power consumed is between 870 and 750-kw-hours if cold scrap is the starting material. If, however, molten metal is taken from an open-hearth furnace or a Bessemer converter and over-blown, and thus delivered into the electric furnace, the power consumption is from 200 to 300-kw-hours in 5-ton furnaces, according to the purity of the product required. With larger furnaces the consumption of power per ton of output is very much diminished. This is indicated by the fact that in a 1.5-ton furnace 48 per cent of the electrically-generated heat is lost by radiation; of course, with increased dimensions the radiation loss per ton of output can be very much diminished. Whenever large sizes of furnaces are used with cheap power, the pros-

pects of competition with open-hearth and Bessemer steel are not so bad, especially if it is considered that the Héroult furnace enables other savings. For instance, it requires little or no ferromanganese, the manganese being reduced directly from additions of ore. Only the theoretical amount of ferrosilicon need be charged and cheaper starting materials lower in grade may be used. However, up to the present the Héroult process has been applied only for the production of high-grade special steels in competition with the crucible process, and in this respect the results obtained at Remscheid are extremely satisfactory.

Prof. Eichoff called attention to two special points which are important, namely, that of deoxidation and that of chemical purity. With respect to the former point he expresses the opinion that the boiling of steel and the occurrence of pipes and blow-holes are mainly due to iron oxides dissolved in the steel. This solution of iron oxides must be prevented, and for this purpose heretofore ferromanganese and ferrosilicon have been added. This has the disadvantage that manganese and silicon when combining with the oxygen form solid oxides, which remain in the steel in a finely divided state. Further, every basic slag contains iron oxides in solution, which will react with the molten bath and a thorough deoxidation is impossible. The special point of the Héroult process is that the slag is perfectly free from iron. With the electric process those elements which can be oxidized, like phosphorus, sulphur, manganese and silicon can be completely controlled; phosphorus, to the extent of 0.003 per cent and sulphur below 0.01. Copper, arsenic, etc., cannot be removed, but these elements are not deleterious themselves but only through their sulphur compounds.

The Héroult process, as carried out at Remscheid, is described as follows: "From a Wellman tilting open-hearth furnace 1.5 to 2 tons of liquid steel, partially purified, is cast into the electric furnace, care being taken to hold back the slag. The bath is covered with an oxidizing slag, and the current is turned on. After the lapse of one-half to three-quarters of an hour the slag is carefully drawn off, the clear bath is covered with a certain amount of carbon and a fresh amount of slag, free from oxides, is charged. This slag is melted after 20 minutes, and then through the action of the arc upon the slag, it is thoroughly deoxidized, calcium carbide being formed. In this manner the bath is completely protected against access of air. The charging of the neutral slag cools the bath so much that the greater part of the protoxide of iron is reduced by the layer of carbon. A certain quantity of manganese ore is also charged with the neutral slag. This, too, is reduced and destroys the last small balance of the protoxide of iron. When the slag has become quite white a sample of the steel is taken and its carbon content is determined. Then a mixture of iron and carbon, accurately calculated, is added, and, when dissolved, the necessary addition of manganese and of ferrosilicon is charged to produce the desired quality. The steel is then tapped. So far as phosphorus is concerned the analysis of the steel in a well managed charge fluctuates between 0.003 and 0.005 per cent, while sulphur ranges from 0.007 to 0.012 per cent. As a rule, carbon, manganese and silicon can be accurately kept within limits of 0.03 to 0.05 per cent."

The elimination of the sulphur takes place during the last stage of the process, and seems to be due to the fact that a much more basic slag can be used in the electric process on account of the much higher temperature available. When the steel is taken in a highly oxidized condition from the Wellman furnace it carries only about 0.01 per cent of phosphorus, and may be directly covered with carbon and the neutral slag. This makes it possible to finish a charge in 1¼ hours with a consumption of power of 200 kw-hours per ton of steel.

There is no danger of the very high temperature spoiling the charge, since there is always thorough circulation in the bath, and all particles in the bath come into contact with the slag, the highest temperature being concentrated in the slag layer.

Prof. Eichhoff quotes some results reached by Guillet, the distinguished Paris metallurgist, on the properties of steel made by the Héroult process in comparison with the best crucible steel. With equal toughness it permits of a carbon content from 20 to 40 per cent higher, and therefore has a greater resistance to wear. It has a strikingly high elastic limit and contraction of area. It is completely free from blow-holes, and, therefore, when the process has been properly conducted, no surface defects or longitudinal cracks appear. It is completely deoxidized and contains no "emulsion" of silica or manganous oxide. The presence of copper and arsenic has no injurious effect, so long as practically no sulphur is present. Segregations of phosphorus and sulphur do not occur. It forges better and stands a higher heat better than crucible steel. The cost of production is far below that of crucible steel. It is independent of the quality of the raw material. Its manufacture is coupled with less exertion for the workmen than that of crucible steel. In purity it excels nearly all crucible steels. The process makes it possible to produce any kind of alloy steels, even such whose analysis has been thought to be impossible hitherto.

Steel produced may be kept for hours under a neutral slag without changing its quality, and a part of the heat may be cast and the balance be worked over to another grade—a matter which is of great importance to steel founders. The steel may be allowed to chill and be melted over again without hurting its quality.

Fixation of Atmospheric Nitrogen.—The *Elektrotechnische Zeitschrift*, of Jan. 10, contains the first part of a paper by G. Erlwein, of the Siemens-Halske Co., on matters connected with the development of the cyanamide process. In the introduction he mentions some work done in the laboratory of his company tending towards the development of a method of producing nitrogen oxides from air by electric discharges. In the first method described an arc is formed between impregnated thick carbon electrodes (such as used in the Bremer arc lamp and in flame arc lamps), and the arc is blown and spread out by means of magnetic deflection. In the second method the arc is made to move and extinguish in the same way as in the well-known horn lightning arresters. In fundamental principle both methods are quite similar to the well-known Birkeland-Eyde process. The main part of the paper, however, refers to the production of cyanamide in the electric furnace, and we reserve a more complete review of the paper for a coming issue, when the complete paper of Erlwein will be available.

Copper.

The Pyrite Process of Smelting at Mount Lyell, Tasmania.—Pyrite smelting at Mount Lyell has been brought to a high standard of metallurgical efficiency by Mr. Robert Sticht, the well-known manager of the smelting works. A general review of the practice at the smelter is given by Mr. R. Nicholls, late assistant manager of the works, in the *Journal* of the Chemical, Metallurgical and Mining Society of South Africa, November, 1906. After reviewing in general the process of pyrite smelting the author begins the description of Mount Lyell practice by giving the analysis of the ore at Mount Lyell, the sample being taken from the open-cut workings of the mine. The analysis shows the following percentage constituents: SiO_2, 2.90 per cent; Fe, 41.2; $BaSO_4$, 2.16; Al_2O_3, 1.63; Cu, 2.4; S, 48.28. The reduction of the ore at Mount Lyell is effected in three stages, the first and second in the blast furnace, the third comprising the reduction of the enriched matte by Bessemerizing. The usual practice was formerly the smelting of the ore in blast furnaces, with the addition of silicious and calcareous fluxes, as well as 2 to 3 per cent of fuel in the shape of coke, using a heated air blast By this operation a matte containing from 12 to 20 per cent copper was produced, the grade varying, of course, with the values in the ores smelted, with an average concentration of

4 to 5 per cent. The recent procedure has been modified by the use of ores which consist of siliceous schists that carry copper in the form of erubescite, chalcopyrite and copper glance. The analysis of these schists is about as follows: SiO_2, 64 to 68 per cent; Fe, 7 to 3 per cent, Al_2O_3, 14 to 20 per cent; Cu, 1 to 5 per cent. A typical slag run in the blast furnaces is as follows: SiO_2, 38.5 per cent; FeO, 46.26 per cent; CaO, 5.90 per cent, MgO .32 per cent, Al_2O_3, 7.47 per cent; Cu, .15 per cent. The second operation consists in concentrating the first matte to a second matte of 45 to 60 per cent copper, the rate of concentration being about 3 into 1. The concentration of the matte in the second operation is carried out on similar lines to the first operation, as it is smelted with silica or siliceous flux, limestone and return slag from Bessemerizing. The matte is then Bessemerized, the final product being a blister copper containing about 98 per cent copper, 60 to 200 ounces of silver per ton and .3 to 7 ounces of gold per ton. Some data concerning the process of pyritic smelting at the Mount Lyell works are also given in an article by Mr. Robert Sticht, the above mentioned manager of the works, in *Metallurgie*, Nov. 22, Dec. 8, 1906. In a recapitulation of his remarks he states that it has not been possible to permanently carry out the ideal pyrite-smelting process, that is to say, the process in its most perfect form, where neither coke nor hot air is required. Even when it was possible to get along for a time without the use of coke, heated blast had to be employed, and at the present time, when the wind is blown in cold, it is necessary to use some coke. If this small addition of coke is omitted, the disturbances which appear after some time, owing to the furnace getting cold and hanging, occasion more loss than the saving in coke is worth. Inasmuch as the Mount Lyell smelter has now reached the limit of its present facilities for blast, nothing can be done in the direction of a greater volume of blast. It is the intention, however, to enlarge the blowing plant in the near future. The furnaces are blown at the present nominally with 17,000, and often 20,000 cubic feet, of air of 48 to 52-ounce pressure per minute, and 95 per cent of the Fe in the charge is oxidized. In reality, the amount of air entering into the furnace is less, because the losses in the blowers are larger than they can be experimentally determined in measurements, and because a considerable part of the air is lost in the flues and at the furnace. The amount of blast at disposal ought to be increased under the circumstances, and this increase should not only serve the purpose to oxidize still more Fe and S, that is to say, to oxidize a compound of sulphur nearer to the mono-sulphide, but in general to carry out more extensively the dynamic processes in the furnace beyond stages reached at the present time. By this means it should be possible to substitute the small number of Calories furnished by the coke, namely, per unit of weight of charge, nominally about 68, but effectively by reaction with SO_2 only about 22, by a greater generation of heat from the ores themselves. An addition of coke hinders, under all circumstances, the oxidation, and it is therefore a disadvantage where the caloric effect of Fe and S as in the present case, should be used as the only source of heat on account of the high percentage of these two bodies. The experiments of Hollway and the process of Bessemerizing copper both show clearly that the use of coke is not absolutely necessary, and the best proof is furnished by the latter process, for the reason that the sulphur compound which initially burns in the converter is identically the same in the pyrite furnace. It is therefore only requisite to run closer to the pneumatic conditions of the Bessemer operation in a pyrite furnace than has been done up to the present time. It is, of course, self-evident that the admission of air cannot be increased up to the point where the flame, so to speak, is blown out again. Mr. Sticht states that it is the intention at Mount Lyell to increase the height of the furnace considerably in the near future, and this should contribute towards reaching the goal of melting pyrote without coke and with cold blast.

Zinc.

Alloys with Iron.—S. Wologdine, in Prof. Le Chatelier's laboratory, has studied these alloys up to 10 per cent of iron; the results are given in *Revue de Metallurgie* for December. The alloys were made by putting small pieces of galvanized iron wire into melted zinc and heating to 700° to 800° in a clay crucible. For using the microscope, polished sections were attacked by a solution of 5 parts iodine in 100 of absolute alcohol, and a solution of lead chloride. Even with 0.07 per cent of iron clear-cut crystals begin to appear, which, by reason of their hardness, stand out on the polished sections. The quantity of these crystals, with clear-cut outlines, increases with the proportion of iron until with 8 per cent they cover the entire surface. On dissolving away the pure zinc entirely by lead chloride solution, the residue showed 8.14 per cent of iron, corresponding pretty well to the formula $FeZn_{10}$. The fusibility curve showed the melting point rising at the rate of 55° per 1 per cent of iron, attaining a maximum of 755° for the proportions $FeZn^{10}$, with 8 per cent iron, then falling off to a probable eutectic of $FeZn^{10}$ with Fe, containing 10.15 per cent of iron and melting at 690°. Alloys with less than 6 per cent of iron showed an arrest while cooling at the melting point of zinc, while the alloy with over 8 per cent of iron showed an arrest at the melting point of the eutectic just mentioned.

Iron and Steel.

Constitution of Iron-Carbon Alloys.—In *Revue de Metallurgie* for December, Prof. Le Chatelier reviews and criticizes the conclusions of Mr. A. Sauveur's article on this subject, read before the Iron and Steel Institute, and abstracted in this journal for September, 1906, page 356. Le Chatelier points out that the distinction drawn by Mr. Sauveur between the solid state and the liquid state, is contrary to the basic principles of the phase rule, which ignores completely any distinctions between the solid, liquid or gaseous states of one and the same substance. The differences between these three states is solely that of a larger or smaller coefficient of viscosity, simply a question of *more or less*, and the drawing of sharp lines of distinction between them is based on no scientific foundation, and is totally immaterial to the application of the phase rule. There are in reality only two distinct states of matter: the amorphous and the crystalline; and even of these the phase rule takes no account, being concerned only and solely with the question of the *non-miscibility* of different phases, and no person has the right to restrict the well-defined field of application of this rule. The only reservation to be made, in applying the phase rule, is that it concerns systems in equilibrium—a limiting state towards which natural phenomena approach indefinitely under any given conditions. Carbon differs in iron, however, as rapidly as salts in water, and iron is the one solid body in which the phenomena of equilibrium approach their most perfect realization. The application of the phase rule by Roozeboom, in his well-known diagram, is therefore perfectly legitimate and correct, and is unaffected by the erroneous criticisms of Mr. Sauveur. Roozeboom affirms simply that the separation of graphite and of cementite from an austenitic solution follow two distinct solubility curves; he nowhere states that free graphite, in the cooling iron, unites with iron to produce cementite, as is charged by Mr. Sauveur. It is simply a case of misunderstanding on the part of the latter. The experiments of Mr. Sauveur, in which he obtained in the same cooled specimen, both cementite and graphite, are easily explained; one rate of cooling causes cementite to separate, another very slow rate graphite, an intermediate rate both. The preparation of cementite is a state of labile equilibrium, which becomes a state of fixed equilibrium—graphite and ferrite—on slow enough cooling.

Rapid-Cutting Steels.—*Revue de Metallurgie* for December contains a leading editorial from the facile pen of Prof.

Le Chatelier, wherein the work of Mr. Taylor on "The Art of Cutting Metals" is reviewed so appreciatively that some of the pleasant things so gracefully said cannot but sound agreeably to the countrymen of Mr. Taylor. Two paragraphs are as follows:

"It is difficult to comprehend the amount of moral energy required for the following of one line of work twenty-five years —as one may say during the term of an average active human life. There is the secret of American preponderance. Immigration has drained towards the new continent most of the enterprising and active elements of the old world; the sons and grandsons of the first immigrants have preserved a part of these qualities. It, on the one hand, this energy in the service of bad passions has created some grand fillibusters of universal reputation, yet it must not be forgotten that in America the same energy is also in evidence in the same degree in men of honor and of industry: Roosevelt, Carnegie, Monsignor Ireland and many others less well known to us.

"Mr. Taylor belongs to this *pleiade* of men of action, who, by the sole force of their wills, have transformed the society in which they live. Since 1900 the industry of machine work has been completely revolutionized in the entire world; this result has been attained by the persevering efforts of one man. It is only justice to proclaim this fact and to express our admiration for such qualities which it would be doubtless difficult for us to imitate on our old and slightly-tired continent. We have, however, like the Romans in the period of the Decadence, still enough appreciation of the best in life to be capable of admiring such characters, as we would admire the finest work of art, and to know how to render homage to them as they pass."

Silicon and Carbon.—F. Wust and O. Petersen, working in the metallurgical laboratory of the Technische Hochschule, in Aachen, have investigated the influence of silicon upon carbon in iron alloys; their paper is in *Metallurgie* for Dec. 22. The primary object of the investigation was to determine the maximum amount of carbon which could co-exist with definite percentages of silicon, as well as to determine the melting or freeing points and the critical points of such alloys. It was found that increase of silicon was accompanied by a steady decrease of carbon and a nearly steady increase of melting point. Iron and carbon alone possess a eutectic of 4.3 per cent carbon, but the introduction of silicon lowers the per cent of carbon in the eutectic; for any definite amount of silicon present there is a definite percentage of carbon which forms the eutectic. The experimental results are as follows:

Per Cent Silicon.	*Per Cent Carbon.*	*Freezing Point.*	(4)	(5)
0.19	4.21	1135° C.	1137	— 2
0.51	4.02	1135	1150	15
1.18	3.89	1145	1158	13
1.44	3.79	1185	1165	+ 20
2.11	3.70	1185	1170	+ 15
2.63	3.48	1185	1184	1
3.28	3.34	1175	1194	19
3.73	3.25	1205	1197	+ 8
3.93	3.17	1195	1205	10
4.82	2.95	1195	1220	25
5.18	2.78	1205	1232	27
13.71	1.84	1215	1326	111
18.97	1.12	1235	1422	187
27.18	0.79	1235	1459	224

The authors speak of the increase of melting point caused by the silicon, but the increase shown is less than would be accounted for by the diminishing of the carbon. The melting point of pure iron being about 1,600°, and carbon diminishing its melting point about 100° per each 1 per cent present, the silicon really reduces the melting point of the carbon-iron alloy. We have, therefore, added two columns to the above table, column four showing the melting point of each iron-carbon alloy without silicon, and column five the reduction of melting point caused by the presence of the silicon. While the lower percentages of silicon give uncertain results, because columns three and four are by different observers, yet there is no doubt that large proportions of silicon lower the melting point of iron-carbon alloy about 8° for each 1 per cent of silicon.

Regarding the halting point in the cooling curve, alloys with up to 3.5 per cent silicon showed only the ordinary perlite formation point, 770°, but above that there was substituted a transformation point at higher temperatures, reaching 930° with the 5 per cent silicon alloy. The microscopic investigations seemed to point to crystals of pure FeSi embedded in a matrix constituted of admixed ferrite and carboniferous Fe^2Si.

NICKEL.

Reclamation from Nickel-Plated Scrap.—Carl Richter, in the *Elektrochemische Zeitschrift* for December, gives a record of some experiments on this subject. The material was sheet iron, heavily copper-plated and then nickel-plated, and after the sheets were used for making cartridges there remains strips about 5 centimeters broad, 0.5 to 1 meter long and nearly a millimeter thick. By analysis these contained 92.49 per cent iron, 6.40 per cent copper, and 1.11 per cent nickel. As they stand they contain too much copper to be desired by the blast furnace or open-hearth steel industry, and if a method could be found to recover the nickel and copper, separating them completely from the iron, the residual iron would find a ready market in the steel industry. Attempts to remove the coating mechanically by the sand-blast and tumbling-barrel were unsuccessful. Better results were obtained by oxidizing annealing, followed by passing the strips through grooved rolls, whereby the oxidized coating sprung off. The iron retained only 0.13 per cent copper, while the scale removed contained 22.70 per cent iron, 35.82 copper, and 12.87 nickel. The scale contained still so much iron that the separation was incomplete and not economical, since a further treatment would be necessary. Finally, electrolytic solution of the nickel and copper was attempted, with satisfactory results. As electrolyte was used, dilute sulphuric acid containing 240 grams H^2SO^4 per liter; the cathodes were sheet lead; the anodes the scrap strips, hung about 7.5 centimeters from the cathodes. A very weak current dissolves the nickel first, because it is on the surface and is more electro-positive than copper. In fact, the local action of Cu — Ni couples facilitates the solution of the nickel. With 0.8 to 1.0 volts bath tension and an average 780 amps. per square meter (70 amps. per square foot) current density, the nickel is dissolved; with 2.5 to 3.0 volts bath tension, and an average current density of 900 amps. per square meter (80 amps. per square foot), the copper is removed along with the simultaneous solution of some iron. In fact, the iron, as soon as exposed, tends to reprecipitate copper from the solution, upon the anode, which it is only prevented from doing by having the current density so high towards the end of the operation that gas is freely liberated at the anode. Copper only deposits on the cathodes, as a loose powder, while the nickel, with some iron, remains in the solution. In twenty-two experiments, with the same bath, the anodes were stripped of all their nickel and copper and 5.1 per cent of iron. The removal of nickel and copper was so clean that the iron could be used in making steel. The solution, when saturated with iron and nickel salts, is to be taken away, electrlyzed with insoluble anodes, to precipitate the copper, and the returning iron-nickel solution worked up in any available chemical manner, either by separating the nickel or to a mixed iron-nickel precipitate which can be used for making iron-nickel alloy. It is to be regretted that the details of this extraction of nickel were not also worked out thoroughly.

Blast Furnace Practice.

Smelter Charge Handling in the Southwest.—The making up and bedding of the charges for blast furnaces is a matter which influences the economy of smelting considerably, and a good deal of attention is paid to it by smelter managers. In practice at three representative works in the Southwest, one of them a large carbon lead and copper smelter, the second, the Copper Queen Reduction Works at Douglas, Ariz., and the third, the smelter of the Greene Consolidated Copper Co., at Cananea, Sonora, Mexico, is outlined in an interesting article by Mr R. B. Brinsmade in *Mines and Minerals*, January, 1907. At the first works the ore is received in railroad box cars, which run on trestles over the bedding bins. The ore is run on wheelbarrows over plank platforms, for distribution on the beds below. An ore bed is 80 feet long but narrow, a shipment of the bed's ore being distributed over it by hand shoveling as evenly as the quantity will permit. No attempt is made to build a self fluxing mixture, but a different place is provided for each separate class of ore, such as "silicious," "iron sulphide," "carbonate" or "copper," a complete charge being made up by mixing a weighed quantity from several classes. The bin sides have slats, which can be taken out for the entrance of mixing cars over tracks along the level floor. These cars are filled by means of a shovel, weighed and dumped into a steel charge hopper, the latter being of rectangular cross-section with sides sloping to the bottom gate, which opens along the whole length of the charging car beneath. When the 4-ton charge of ore, slag and flux has been dumped into the hopper, it is run into the charging car underneath. This car is fitted with an electric motor and trolley, and after receiving the ore, charge is run under a similar hopper where the requisite amount of coke is dropped in. It then goes to a hydraulic platform elevator, which lifts it to the feed floor of the furnaces, 32 feet above the tapping floor. To avoid the long drop from the feed floor to the top of the smelting column of the furnaces, a hopper is placed on each side of a furnace, into which hopper the charging car dumps its contents. The gates in these hoppers are then opened, and the charge is thus let into the furnace with very little fall. The practice at the Copper Queen smelter, the ore trains from the mines are run over tracks between the charge pits, the latter being 40 feet wide by 11 feet deep and 800 feet long, having a capacity of 15,000 tons, one longer pit has a capacity of 20,000 tons. For bedding the pit length is attacked in 200-foot sections, and one 300-ton ore train will cover the 800 square feet of area to a depth of 9 inches. The ore is spread evenly by a plough, a framed adjustable wooden scraper moved by an electric locomotive. When one section is nearly full of ore, its average composition is calculated from the samples taken, and enough special ore and limestone is added on top to make the bed self fluxing. An ore pit is emptied by a steam shovel running on a central track along the floor. This shovel lifts the ore into a train of twenty charging cars on a track above, drawn by an electric locomotive. The train is run under hoppers from which the coke is dropped into each car simultaneously. The bedding of the limestone with the ore is stated not to have been a success, and it will soon be handled from bins like the coke. As the coke is on top, it falls below the charge when a charging car is tipped into the furnace. The drop to the smelting column is 0 feet, which causes a good distribution of the feed. In the system in use at the Greene smelter the ore is broken to 2½-inch size, and finally falls onto a conveyor belt, which, by means of a movable tripper can discharge into any one of three conveyors, each of which feeds a bed 400 feet long. One bed is filling while the other is being emptied, the third being held in reserve. The latter conveying belts are discharged by a continuously-moving tripper, which travels forward at the rate of 500 feet per minute and backward at the rate of 250 feet per minute, thus making a round trip in 2.4 minutes, or once for each 8 tons of ore bedded when running at the rate of 200 tons per hour. When 10,000 tons, or three-fourths of the bin's capacity has been reached, the elements necessary to make the required slag are added, the missing elements, as far as possible, being added in the shape of ore, the limestone being added last and finally the coke. When a bed is completed it is emptied by an automatic shovel, which consists of an endless chain belt on a carriage on rails, which carries buckets that fill themselves, across the whole bed width, thus securing constantly an accurate cross-section of the whole bed from apex to base. By a series of belts the charge is finally brought to the furnace feed floor, where it is automatically delivered to the various furnaces. In addition to the description of the bedding practice the author also gives an outline of the methods of sampling and dealing with the flue dust adopted at the various works. He concludes from general considerations in favor of the method adopted at the Greene Consolidated smelter as giving a more uniform charge.

Gold and Silver.

Wet Crushing and Concentration in Western Australia.—Mr. R. Hokes in the *Mining World*, Jan. 12, gives a review of metallurgical practice in the Kalgoorlie district. According to him the Diehl process of bromo-cyanidation, as now practiced in the district, where it found its first application, involves the following vital operations: 1. Wet crushing of the ore in stamp batteries with or without amalgamation. 2. Classification of the pulp by spitzkasten and Wilfley tables. 3. Elimination of the concentrate, equivalent to 5 or 6 per cent of the mill product, which constitutes the most refractory portion of the ore. 4 Desulphurization of the concentrate and subsequent fine grinding, amalgamation and cyanide treatment. 5. Fine grinding of the lighter material by tube mills or grinding pans, and the treatment of the resulting slime with bromo-cyanide. The weight of the stamps used is stated to range from 1,100 to 1,275 pounds, dropping on an average 105 times per minute 7½ or 8 inches. The boxes are fed with weak cyanide solutions of 0.01 to 0.04 strength. At the Oroya-Brownhill mill the product passing the 100-mesh battery screen is divided into fine and coarse sand; the latter is reground in Wheeler pans before going to the Wilfley tables. The product of the primary Wilfleys, separated from the heavy concentrate, is passed over eight rows of spitzkasten, the course sand from which is fed into tube mills, the fine sand goes to secondary Wilfleys and the slimes to the pulp condensers, ready for the bromo-cyanide vats. The tube mill product is continually returned to the spitzkasten. The author states that the reasons given for using tube mills for sliming with the Diehl process, while Wheeler pans are employed for fine grinding, with excellent results, are not especially conclusive, it being generally contended that these cumbrous machines are better adapted to the production of the very fine slime required and that as they shed less iron than the Wheeler pans, less KCy and BrCy are consumed in the subsequent treatment. There are now 22 mills in use in the district, namely, 10 at the Golden Horseshoe, 6 at the Lake View and 6 at the Oroya-Brownhill. The mills at the Golden Horseshoe are 16 feet 4 inches long by 4 feet diameter; 30 r. p. m.; horse-power required, 30; life of liners of chilled cast iron, six months; charge of imported flints, 5 tons. In the author's opinion the most urgent need in connection with the Diehl process to-day is for an efficient slime table for the recovery of the fine concentrate lost by the Wilfleys. Wilfley slime tables have been tried at two mills, and have been found practically useless for the purpose. The agitation of the raw slime with bromo-cyanide is effected in closed vats, and is completed in about 12 hours. The bromo compound is added an hour or two after the commencement to the amount of ¾ pound per ton, varying according to the value of the pulp. The cost of treatment per ton of slime at the Lake View and Ivanhoe is given as follows:

	Ivanhoe.	*Lake View.*
Tonnage	90,300	104,500
Labor and salaries	$0.05	$0.05
Power	.07	.00
Repairs and maintenance	.02	.02
Assaying and sampling	.03	.01
Water	.06	.02
Cyanide	.43	.26
Bromo-cyanide	.53	.38
Royalty	.07	.08
Lime	.01	.01
Sundries	.01	.01
Totals	$1.28	$0.99

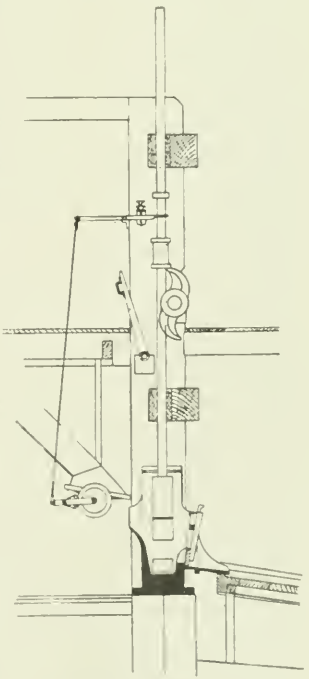
Filter pressing is also a costly operation, the labor required averaging 22 per cent of the total mill labor forces. The following are the costs of filter pressing at the above two mills:

	Lake View.	*Ivanhoe*
Labor and salaries	$0.20	$0.22
Power	.16	.05
Repairs and maintenance	.06	.02
Assaying and sampling	.02	.02
Sundries	.02	.01
Total	$0.46	$0.32

For other mines the total per ton pressed are 38c., 30c., 32c. and 30c. A patent automatic vacuum filter press is stated to be on trial with thus far promising results. In summing up the metallurgical position at Kalgoorlie, the author comes to the conclusion that whereas the all-roasting process has now been brought to a high state of efficiency the wet-crushing process may yet be bettered, both in regard to extraction and cost. He believes that as things stand, the all roasting plants may, perhaps, claim superiority, but by the introduction of some means for the more perfect elimination of the finely divided sulphides or slime concentrate, the wet process may yet be able to gain the distinction of undoubted economic priority.

A New Cyanide Plant.—The recently-adopted method of sliming the ore by means of tube mills previous to cyanidation has led to considerable modifications in the design of cyanide plants. An outline of the process to be followed in a modern mill, illustrated by a plan of the mill, is given by Mr. M. R. Lamb, in the *Mining and Scientific Press*, Dec. 29. The ore to be treated has the following characteristics: Gold, $7.00 per ton; silver, none; concentrate, 5 per cent; free gold, 5 per cent; lime required to neutralize, 10 pounds; cyanide consumed per ton, 1.2 pounds; concentrate value, $400; the ore is rather softer than ordinary California gold-bearing quartz. The ore goes to the stamps in a size not exceeding 1¼ inches. The stamps will weigh 1,600 pounds, five stamps to a shaft, with a cam shaft 7.5 inches in diameter. The plant is expected to treat 140 tons per day, crushing to a maximum of 150 mesh. The stamp stems will be 4 inches in diameter. Crushing will be done in cyanide solution, Muntz metal upon plates being used. The design shows cone classifiers below the battery plates for roughly separating the sand from slime before concentration on vanners. The tailings from the vanners go to a large dewatering cone, the underflow of which feeds the tube mills. The author mentions that the cones will probably be replaced by a Dorr classifier, as the sand can be sent to the mill by the latter with much less water, and thus in better condition for efficient work in the tube mills. The latter are 12 feet in diameter, and are lined with soft iron plates, 1 x 8 inches x 12 feet; the joints are covered with 3 inch angle iron, 12 feet long. It is expected that this lining will last twelve months. From the mills the pulp will go to cones or to a Dorr classifier, the oversize returning to the mills, while the slime goes to a 6-foot thickening cone. It was hoped that slime tables would be satisfactory for concentration at this stage of the process, but it has been ascertained that a canvas plant is the only means of extracting all the mineral. With a 10 foot width per ton of dry pulp there would be required a distribution length of 1,400 feet, with a width of canvas of at least 10 feet. Placed on two floors, the space required for the canvas plant would be 17,000 square feet. The remainder of the plant consists of settlers, agitators, which latter are equipped with reaction devices for compressed air, and a slime storage vat, whence the slime is taken to a vacuum filter for washing. The overflow from the settlers and part of the overflow from the filter is sent to the battery sump and is pumped therefrom to the battery supply vat. The solution drawn through the filter passes through a clarifying press on its way to strong and weak gold vats, and from the latter it is pumped through a Merrill zinc dust precipitation press and returned to the battery sump. The slime cake is first washed with battery sump solution and then with water enough of the latter being used to make up for the loss by evaporation and as moisture in the residue. The labor in a mill such as outlined will consist of one battery man, one concentrator and tube mill man, one canvas man and one cyanide man, the cost of which, together with superintendence, will be about 55 cents per ton milled with a 20-stamp mill. The total working cost is expected to be well below $2.50. When the mill is increased to 40 stamps the labor will be increased by one battery helper and one canvas man per shift, making a total of 36 cents per ton milled and bringing the cost to less than $2.00 per ton milled.

Some Accessory Stamp Mill Appliances. Stamp milling in the large mills of the Witwatersrand has been brought to a high state of efficiency and the recovery figures obtained and the stamp duty are probably unsurpassed anywhere in the world. In a paper read before the Chemical, Metallurgical and Mining Society of South Africa, published in the November issue of the journal of that Society, Mr. G. O. Smart gives some data concerning the details of construction of stamp mill machinery in use at the Simmer and Jack Proprietary mines. He illustrates the arrangement of driving the Challenge feeders as represented in the accompanying diagram. It will be noted that the rocking bar or feeder arm is removed from the top of the mortar box and the ore chute, and is placed on the king post under the top guide block. Power to drive the gear is transmitted by means of a manila rope ½ inch or ⅝ inch in diameter. The center box, fulcrum bracket, the connecting rod, the springs, etc., are no longer required, and a wood bearing is placed on the horizontal shaft which can be adjusted to act as a slight brake. This construction helps to steady the shaft, and, by keeping the teeth of the



STAMP MILL CONSTRUCTION

...ment of this kind. 1. The feed is adjusted from the cam platform by the amalgamator who is testing the stamps, without his having to go downstairs and around to the feeder platform in order to make the adjustment. 2. When the center tappet is set, the box is fed by the man that works on the cam platform by an increased pull on the ½-inch rope instead of having a man feeding up the box from the feeder platform. Furthermore, the transmission of power by means of a small rope gives a very easy and steady movement to the gear instead of the usual hard knock and jar, and thus the wear and tear on the feeder parts is reduced to a minimum. The removal of the feeder ring from the top of the mortar box allows of a wood housing being put around or a mortar with a higher top may be used without having to raise the bottom guide blocks, and thus take them further away from the stamp heads. With a deeper top to the mortar box, longer heads, or larger shoes and dies, can be used to increase the weight of the stamps. The author also finds the hydraulic press a great convenience for removing the broken stem ends from the heads. The machine is set up inside of the mill and one man can remove the broken stem end from the stamp head in a few minutes. The experience of the author in this respect was confirmed in the subsequent discussion of the paper by Mr. J. P. McKeown, who estimated that the hydraulic extractor would save 60 per cent of the expense usually incurred in this operation. The author also finds that a solution of hydrochloric acid of 1.6 per cent, or about 1 in 20 of the commercial acid, makes a very good substitute for 0.9 per cent cyanide solution when applied only to the parts of the plate where some discoloration or film was apparent, and when used at the end of the dressing operation, just before water was again turned over the plate, so that the contact was as short as possible. He always found a value of from 6 to 8 dwt. of gold in solution in the first flow of water coming over the table after dressing, and a steady 0.02 dwt. was returned as the value in the clear water overflow from the slimes collectors. Since stopping the use of cyanide in the mill altogether and using hydrochloric acid, only when required, he has never had more than traces of gold returned as the value of the clear water from the slime collector.

RECENT METALLURGICAL PATENTS.

Zinc

Zinc Furnace.—William Lanyon, of Iola, Kan. (839,160, Dec. 25, 1906), patents details of construction of a zinc furnace with the object to obtain a gradual and perfect combustion of the fuel, "thereby producing not only economy in fuel, but at the same time a more uniform and desirable character of combustion and consequent steadiness of temperature in the retort-furnace chamber, which results are highly essential for the proper volatilization and distillation of the metallic zinc, and likewise for the saving of the retorts or muffles from destruction usually resulting from spotted, irregular and uncontrollable heats." The fuel is taken in at the lower end or bottom of the furnace chamber, where the fuel is ignited, and the fire and heat thus obtained naturally pass upwardly through the retort chambers, strike against the furnace roof or arch, and are deflected thereby downwardly, and the flame and heat are withdrawn from outlets at the bottom of the furnace. This arrangement, together with the admission of air for combustion at the proper points, produces a condition whereby the air and gases are very easily mixed and intermingled. This naturally results in an easily regulated perfect combustion. The special means by which this result is obtained are well indicated by the ninth claim, which reads as follows: "A zinc furnace, constructed with a center wall, there being a flue centrally arranged in said center wall, means whereby air and gas are delivered into the ends of the furnace through the base of the center wall, inlet openings from the exterior of the furnace through the top of the center wall at the ends of the furnace, inlet openings formed through the end walls of the furnace, and means whereby the air and gas during combustion are led upward between the retorts in the ends of the furnace and downward between the retorts at the center of the furnace, and the products of combustion discharging through the flue in the center wall."

Complex Sulphide Ores.—Zinc and other metals like nickel, cobalt, manganese, copper and cadmium are extracted from complex ores by the following method of W. G. Rumbold and G. Pitchin, of London, England (832,341, Oct. 2, 1906). The ores are crushed to 40-mesh per inch and subjected to an oxidizing roasting until the sulphur is removed as far as possible. The ore is then treated with a solution consisting of about 1 per cent of ferric sulphate, ten parts, by volume, of commercial sulphuric acid and a small proportion of sodium chloride, the latter ingredient varying in quantity according to the composition of the ore to be treated, but in no case being sufficient to dissolve the silver chloride which may have been formed. These ingredients are dissolved in 100 parts of water. The effect of this treatment is that all the sulphuric acid radicals in the solvent are used in dissolving zinc compounds or other metallic compounds from the ore without the production of ferrous compounds, and a neutral solution is obtained which is entirely free from salts of iron. "The results, therefore, attained by this invention are the production of a pure and white zinc oxide suitable for paint and other commercial and metallurgical uses from complex sulphide and oxidized ores containing zinc, and the recovery also as by-products of any copper, manganese, nickel or cobalt there may be in such ores." The idea of using a composite solvent consisting of small parts of ferric sulphate and sodium chloride and a larger part of sulphuric acid, is that the oxides, sulphates and carbonates of zinc, copper, manganese, etc., are dissolved by the ferric sulphate, which is thereby decomposed but at once regenerated as long as there is free sulphuric acid in the solution. Sodium chloride is added in order to yield hydrochloric acid by reaction with sulphuric acid; the hydrochloric acid dissolves such portions of the metallic compounds which would otherwise not be attacked. The solution in which the metallic values are thus dissolved is then treated as follows: The saturated solution is first treated with zinc dust, by which copper, arsenic, antimony, lead, bismuth, cadmium and tin are precipitated. It is then filtered and treated with an oxidizing agent to oxidize and precipitate the manganese as hydrate. For this purpose potassium and sodium permanganate are most suitable, and when they are used the manganese in solution, together with that in the permanganate, is precipitated as manganese dioxide or in the form of a hydrate. The nickel and cobalt are precipitated as the hydrated oxides from the solution by the proper addition of bleaching powder. The solution is finally treated with just sufficient ammonium hydrate to decompose the zinc salts in solution, and hydrate oxide of zinc is precipitated, which is separated by filtration, washed and ground.

Lead

Alloy.—G. F. Allen (839,444, Dec. 25, 1906) patents a composition of lead-copper-nickel alloy which is claimed to have greater tensile strength than other soft metal alloys and to be much less subject to corrosion. The proportions in which the metals are used vary according to the nature of the lead used, and are from one-twentieth of 1 per cent to 4½ per cent nickel, and from one-twentieth of 1 per cent to 4½ per cent copper, and the balance lead, and preferably soft lead.

Precious Metals

Treatment of Pyritic Ores.—A patent of W. Blackmore and A. Howard, of London (839,451, Dec. 25, 1906), refers to

the removal of iron pyrites from pyritic ores containing gold and silver. The ore is pulverized to about a 30-mesh, and is then oxidized in a furnace at a temperature of about 800° F. by passing steam and air in regulated quantities through the furnace. The steam is added to modify the oxidizing action of the air and in such proportion as to prevent excessive local action. The effect of this treatment is to convert the iron pyrites into either a normal or basic sulphate or a mixture of sulphate with oxide of iron, and the operation is regulated with a view to the production of a maximum proportion of sulphate. The roasted ore is then leached with a 5 per cent solution of sulphuric acid, and thereby not only the iron but also the copper, cobalt and nickel are dissolved. After separation from the liquor the solid residue containing the gold and silver are treated by suitable extraction processes. The acid liquor necessary for solution is obtained from the sulphurous gases evolved during roasting.

Cyanide Process.—H. B. Goetschius (840,840, Jan. 8, 1907) endeavors to obtain a more complete extraction of gold and silver by a cyanide solution with greater rapidity by the following means: Besides accessory apparatus and tanks there is a solution tank and an ore tank. In the solution tank compressed air is dissolved in the cyanide solution under pressure and the solution is then forced through the ore (which rests on a false bottom in the ore tank) against a back pressure, so that the original pressure is maintained. The pressure is then released, whereby the air is disengaged from the solution and the bubbles of air thoroughly agitate the ore. Finally, the pressure is increased again slightly above the original value in order to redissolve the disengaged gas together with any films or bubbles adhering to the particles of ore. It is, of course, understood that the oxygen in the air is required together with the cyanide solution for thorough extraction.

Modified Cyanide Process.—John A. Just (841,983, Jan. 22, 1907) endeavors to enlarge the scope of the cyanide process to make it applicable to the treatment of such ores which contain substances which with ordinary treatment would retard the extraction and consume the cyanide. For this purpose he subjects the ore to a preliminary treatment, by means of which substantially all these deleterious substances are removed. The ground ore is subjected to the following treatment, in order to render the objectionable minerals in the ore soluble and then to remove the soluble salts formed by leaching and washing. The cleaned sands are then ready for the regular cyanide treatment. The ore to be treated is first reduced to a suitable mesh and dilute sulphuric acid is added thereto sufficient to cover the ore, about 3 parts of sulphuric acid of 1.25 specific gravity to 1 part of finely ground ore or tailings. An oxidizing agent or oxygen salt (such as manganese, dioxide, sodium nitrate) is preferably added to the sulphuric acid and the mass heated. According to the nature of the ore more or less strong acid is required or more or less oxidizing agent should be employed, and also the time of heating required to render the extraneous minerals soluble or inert depends upon the amount of such constituents in the ore. Silver present in quantity in the gold-silver ores is thus removed and goes into solution, while the porous and readily soluble gold will remain in the sands, to be extracted in the subsequent process of extraction.

Chlorination Process.—W. V. Lauder (841,328 and 841,329, Jan. 15, 1907) modifies the chlorination process as follows: The ore is treated within a long chamber consisting of a series of riffle pipes following each other in cascade form. At one end of the long chamber both ore and chlorinated water are introduced, which are mingled together and proceed along the chamber as one stream, being agitated by the riffle ridges and still further agitated by falling in cascades from one riffle plate to the next. If the chlorinated water entering the chamber carries chlorine in sufficiently concentrated solution, an atmosphere of chlorine will be thereby maintained in the riffle pipes. The presence and maintenance of this atmosphere of chlorine is of value, since it regenerates and reinforces the solution during the progress through the chamber. The unsoluble portions of the mass of metal containing earth or rock are detained by the riffle plates and retarded and classified according to their size, specific gravity, etc. The grooves between the riffle ridges gradually fill up with these insoluble concentrates.

Iron.

Iron Reduction in Rotary Kiln.—Attempts to reduce iron ore in a rotary kiln into which the ore mixed with carbon is fed at one end, meeting in the kiln a high-temperature flame from the other end, are not new, but it is known that former trials of this kind were unsuccessful. The carbon mixed with the ore burned away before it reached the lower part of the kiln and did not act as a reducing agent; very little of the ore was reduced to metallic iron, although a large portion of it was reduced to ferrous oxide. Since the carbon burned near the end where it was fed into the kiln, and where the products of combustion left the kiln, there was a large loss of heat by the gases leaving the kiln. Carleton Ellis (839,126, Dec. 25, 1906) has again taken up this problem, with a special view of reducing finely divided ores of pure magnetite or magnetic concentrates without briquetting them. In order to avoid the results of former experimenters sketched above, he points out that it is necessary to subject the ore to a sufficiently high temperature and at the same time to do this in a reducing atmosphere. This is accomplished in the manner already sketched in an abstract of a former patent of the same inventor (our Vol. IV., page 74) by the employment of two flames of different characters, the one carrying an abundance of air, and therefore having a high temperature, and the other having insufficient air or no air at all. For the attainment of the reducing conditions the latter flame is interposed between the high temperature flame and the ore. Another method of securing the reducing conditions is to enter carbonaceous material at some point in the path of the travel of the ore, at a point near the final zone of reduction. By means of the hot products of combustion, which should contain carbon dioxide only and no carbon monoxide, the cold ore is preheated when entering the kiln.

Briquetting.—In our Vol. IV., page 510, we give an illustrated description of the Grondal process for briquetting finely divided iron ores, which is in successful operation in various plants, especially in Sweden and Norway. It is evidently to this process that the patent of F. J. Bergendal (832,358, Oct. 2, 1906,) refers. Since the principles were fully dealt with in our former article, it must suffice to state that this patent refers to details of construction.

Combined Bessemer Converter and Open-Hearth Process.—To produce steel very low in phosphorus and sulphur, and of an exact desired low silicon content, by means of the acid Bessemer converter process, very pure ores are required. H. H. Weaver and G. E. Thackray (837,508, Dec. 4, 1906) try to make the acid Bessemer process of greater general application by combining it with an open-hearth furnace in the following way: From a series of blast furnaces handling ore of no particular selection, comparatively irregular quantities of pig iron are charged into a receiver or mixer containing approximately one or more hundred tons of molten metal. At the same time pig iron of about the same quality is introduced into an open-hearth refining furnace, which is provided with a basic lining of such a character as to aid in the elimination of phosphorus, sulphur and silicon. Basic additions may also be made to the charge in this furnace, so as to eliminate almost all of the silicon, from 80 to 100 per cent of the phosphorus and a reasonable portion of the sulphur. The refined metal is then added to the contents of the large receiver or mixer mentioned above, yielding a bath so constituted in sulphur, phosphorus and silicon that it can be treated directly in an ordinary acid Bessemer converter.

BOOK REVIEWS.

Producer Gas. By J. Emerson Dowson and A. L. Larter. 8vo., 295 pp., 73 illustrations. Price, $3. Longmans, Green & Co.: London and New York.

A splendid treatise by the mentor of the producer-gas power industry. For thirty years Mr. Dowson has improved gas producers and gas engines, exhibiting in 1881 at the Paris exhibition his first complete apparatus, and since then being continuously immersed in this rapidly improving subject. Of the fifteen chapters, three, covering 60 pages, are on the theory of producer gas, and in them we find this branch of the discussion most clearly and scientifically set forth.

An especially commendable, withal surprising feature (Mr. Dowson will pardon us, we feel sure, for saying "surprising"), is that the authors have dropped pounds, ounces, cubic feet and Fahrenheit degrees, and come out squarely on the metric system. Appreciating the courage it took to do this, in Great Britain, we heartily congratulate the writers on their broad-minded position and the excellent result it must exert on English technical literature, in general, and has exerted on this treatise, in particular.

Eight chapters (157 pages) deal with the technique of construction and operation of producers and properties of the gas. These are most practically and lucidly written, showing all through that the treatment is by one who is master of the subject "from a to izzard."

We take issue with the authors only on two points, in this part of the work, one concerning the calorific power of a fuel or gas, the other the manner of calculating its calorific intensity. If a fuel or gas is consumed in a calorimeter, the water formed is condensed to liquid, and a considerably higher calorific power is observed than it is ever possible to obtain in practice, where this heat of condensation is never utilized. We believe that the calorimeter value should always be corrected to the practical value, by subtracting this latent heat of condensation, and only this practical value charged against any furnace using fuel or credited to any furnace producing gas.

Dowson and Larter believe that in calculating the heat balance sheet for a gas producer or in calculating its efficiency, the *gross* calorific powers of the coal and gas should be used. If the authors could have cited any single case in which the products of combustion are cooled to such a point that this latent heat in question is usefully applied in the apparatus, they would have had justification for saying that the *gross* calorific power "will be useful for certain purposes." But there are no such cases, in practice, and therefore the *gross* calorific power is a practical delusion, an unapproachable *ignis fatuus* which has no useful or justifiable place in practical heat calculations. Its use may lead to a very serious distortion of the heat balance sheet, as was explained by Dr. J. W. Richards in this journal, May, 1905, pp. 187-9.

The other point we criticize is the rather clumsy way in which the calorific intensity of a fuel is calculated, by a series of approximations, instead of by the exact method using algebra, involving nothing harder than the solving of an equation of the second degree. True, Damour of Paris uses this arithmetical method, and is also followed by Quencau, and possibly it is more easily understood by practical men who know little or nothing of algebra, but the average technologist knows enough mathematics to use and apply the more elegant and more expeditious algebraic solution. (See also above reference.)

The four chapters (67 pages) on gas engines and gas-power plants are above criticism. No better discussion, in the limited space available, has appeared anywhere.

Altogether, the book is highly commended as the most scientific and generally reliable work on this subject in the English language.

Niagara Falls Power.

In accordance with the Burton bill, which limits the amount of water to be taken from the American side of the Falls to a specific number of cubic feet per second, and restricts the amount of power to be imported from the Canadian side into the United States to 160,000 hp., Secretary Taft has now made the following decision as to the division of the total amount among the different power companies.

The total of 160,000 hp. imported from Canada is divided as follows: To the International Railway Co., 1,500 hp.; to the Ontario Power Co., affiliated with the Niagara, Lockport & Ontario Co., of New York, which transmits power to Lockport, from Lockport to Buffalo, and from Lockport by way of Rochester to Syracuse, 60,000 hp.; to the Canadian Niagara Falls Power Co., 52,500 hp., and to the Electrical Development Co., 46,000 hp.

The International Railway Co. had asked for a permit for 8,000 hp., the Ontario Power Co. for 90,000, the Canadian Niagara Falls Power Co. for 121,500, and the Electrical Development Co. for 62,500. Thus none of the companies got nearly as much as they desired.

In the matter of diversion of water on the American side, Secretary Taft decided that the Niagara Falls Power Co. be permitted to use 8,600 cubic feet per second, the Niagara Falls Hydraulic Power Co. 6,500 cubic feet a second, and the Erie Canal 400 cubic feet a second.

Secretary Taft states he has reached the conclusion "that with the diversion of 15,500 cubic feet on the American side and the transmission of 160,000 hp. from the Canadian side, the scenic grandeur of the falls will not be affected substantially or perceptibly to the eye."

A committee of three has been appointed by Secretary Taft to report on the possibility of harmonizing the commercial buildings at Niagara, particularly the power plants, with the natural beauties.

The power permits will be effective for three years—the life of the Burton bill. If at the end of six months from the time of actual operation under the permits, no depreciation in the beauty of the Falls is shown, Secretary Taft is empowered to issue permits for additional power.

Multiple Scale Switch.

Ever since the invention of multiple scale voltmeters there has been great need for a simple device to protect them against injury as result of wrong connections. Every one knows how easy it is to connect (by mistake) a high potential to the low reading side of a voltmeter, the result being at least a bent pointer and frequently a burnt-out coil. In addition valuable time is lost, to say nothing of the annoyance.

The American Instrument Co., recognizing the necessity for some such device, provide for it in the following way: All of their portable voltmeters which have more than one range are provided with a "multiple scale switch," which makes it practically impossible to injure the instrument by careless connection or through ignorance. This switch is shown in the adjoining illustration. It is placed on the instrument where it is easy to use and operate.

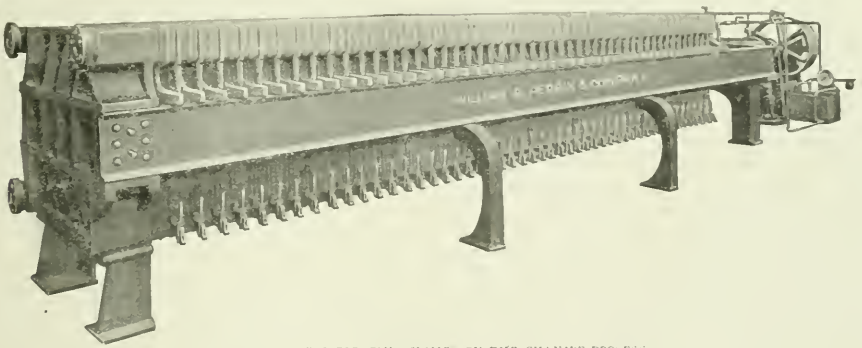
Normally the indicator stands at "open" as shown. Connection is made to the one pair of binding posts no matter what range is wanted; then the button is turned till the indi-

cator points to the range desired and the readings are made. The switch is securely held in position for the required range until the operator is through, then either by pushing a button or closing the lid of the instrument it is released, and flies back to the open position. Thus the switch always stands at "open" when the instrument is not in use, and it is impossible to use the low range without connections having first been automatically made to the higher ranges. Consequently the operator is forced to think and see exactly what he is doing, thereby affording the best protection conceivable against carelessness or absentmindedness. Mr. James G. Biddle, 1114 Chestnut Street, Philadelphia, is the general sales agent for the company.

Filter Presses for Slimes Treatment.

During the past years we have repeatedly recorded new developments in the treatment of slimes in the cyanide process, relating especially to regrinding in tube mills and to the use of filter presses for separating the slimes from the cyanide solution in which the precious values are dissolved. This method apparently originated in Western Australia, but now gradually conquers the world of good metallurgy and finds especially growing application in this country.

The adjoining illustration shows a 5-ton filter press, built by



FILTER PRESS FOR TREATING SLIMES BY THE CYANIDE PROCESS

Messrs. William R. Perrin & Co., Forty-sixth and Looms Streets, Chicago, Ill., for the Echo Mining Co., Navajo, Cal. Another one of these presses has been furnished by the same manufacturers to the Horseshoe Mining Co., while a 3½-ton press has just been sold by them to the Vindicator Consolidated Gold Mining Co., of Denver.

This press embodies the best features of the foreign type of press which is so successfully used for the treating and washing of slimes. This press is of the kind known as "flush plate and division frame type," in which the plates are flat without recesses, and the chamber is formed by a division frame, the width of which determines the thickness of the cake. In this press all feed and exit channels are formed in projecting lugs, and are made tight by means of rubber rings set into the metal surfaces, thus allowing the use of cloths that do not have to be perforated to match the feed and exit channels, in this way saving a great amount of time and inconvenience in setting up and admitting of a much tighter press.

The exit is provided through a drip cock at the bottom of each plate, or is arranged to pass through a closed channel extending through the press. The former plan has the advantage of locating a defective cloth on the press, and enables that particular plate to be cut out by closing its particular drip cock, through which a cloudy solution would be passing. The closed delivery channel on the other hand saves a little time in the operation of the press, there being no cocks to open and close each time the press is filled, and where the final solutions are strained through a clarifying press to remove all trace of solids, the closed delivery type may be considered desirable.

Attention may be called to the arrangement of channels in this press, which are such that the treating solution or wash water must pass through the cakes from one side to the other in the most direct and uniform manner, and the drying of the cakes is effected with complete satisfaction by passing compressed air through the press.

Another type of filter press, built by Messrs. William R. Perrin & Co., is for the separation of the precipitates in the chlorination process. This type has been adopted as the standard by the chlorination plants in Colorado and elsewhere. With this type of press filter paper is used in conjunction with filter cloths, and the paper is stripped off and burned to recover the values. The cloth is eventually burned for the same reason. These presses are universally of the closed delivery type, and no trouble is experienced on account of the defective filtering surfaces when the presses are fitted up with ordinary care.

The same form of press which is used for the chlorination process is recommended for the separation of zinc dust precipitates in the cyanide process.

Messrs. William R. Perrin & Co. also build a round-pattern center-feed type of filter press of the simplest construction for general quick separation of solids held in suspension and for drying the same into solid cakes.

Fused Quartz for Pyrometer Tubes and Other Uses in Chemical and Metallurgical Engineering.

Cracking from quick temperature changes is caused in glass, porcelain and fire clay, because those materials expand or contract as they are heated or cooled with the result that a difference of temperature between the surface and interior or any two parts of one piece produces internal stresses that the material is not strong enough to resist. It so happens that pure silica has an exceedingly small coefficient of expansion, and being free from internal strain, no matter what extremes of temperature are developed in one piece, it has naturally no tendency to crack from either heating or cooling.

Silica is now melted in the electric furnace and shaped into crucibles, muffles, dishes, tubes, plates and pipes, and such articles made of the pure silica do not crack, even with the most sudden and violent temperature changes.

It is almost startling to see articles of this material heated to a red or white heat and plunged into cold water without the development of even a crack. Similarly it may be taken out and plunged into molten metal without damage to it.

According to the recent investigation of H. D. Minchin (*Phys. Review*, January, 1907) the coefficient of expansion of fused quartz is uniform from room temperature to the highest electric furnace temperature used in the experiments, and amounts to 0.44 × 10⁻⁶. This means that fused quartz expands 1 part in 2,230,000 parts for 1° C., or 1 part in 4,010,000 parts for 1° F. For comparison we give some figures from Trautwine's pocketbook. A glass tube expands 1 part in 214,200 parts for 1° F.; i. e. its expansion is almost 20 times larger than that of fused quartz. Black marble (which is about that substance in Trautwine's table which has the smallest coefficient of expansion) expands 1 part in 405,000 parts per degree F.; i. e. its expansion is still 10 times greater than that of fused quartz.

Why does a glass vessel crack when it is, for instance, suddenly heated from the outside? Because the temperature of the outside surface rises more quickly than the temperature of the inside surface, resulting in a difference of expansion of the glass outside and inside. This difference of expansion or this non-uniformity of expansion—which sets up stresses in the glass resulting in a crack—is reduced 20 times if fused quartz is substituted for glass. This figure is a good illustration of the enormous superiority of fused-quartz articles over glass articles for all purposes where sudden changes of temperature are unavoidable.

This fused silica softens slightly between 1400° and 1500° C. (or about 2550 and 2730° F.). Its melting point is above 1500° C. It is of good body, hard and strong. The inside surface of most shapes is glassy, and the other surface quite smooth.

Tubes may be had of numerous diameters from 1-16 inch to 1 inch inside measurements, and up to 5 feet long, and even larger tubes in shorter lengths. These tubes made with closed ends should bring back into use many a Le Chatelier pyrometer which has been laid away because of the great expense of continually buying porcelain tubes to protect the thermocouple wires. Those porcelain tubes that will stand the very high temperatures are necessarily somewhat high priced and they are prone to crack without warning and result frequently in a spoiled couple as well as a broken tube.

On the other hand, the tubes of fused silica give no such difficulty. Not the least interesting feature is that the fused silica tubes are less expensive than the porcelain.

It is the very reasonable price at which the articles of fused silica are being introduced into this country by the Wilson-Maeulen Co., 110 Liberty Street, New York, that insures wide interest in and usefulness for the material. Fused silica as they supply it is milky white and not transparent.

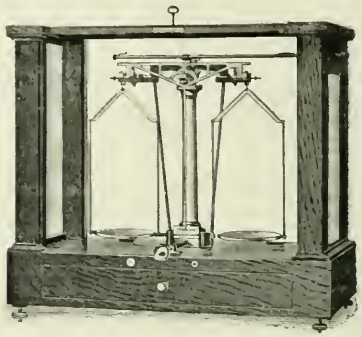
It may be of interest to many to know that they may now use their thermoelectric pyrometers to make temperature determinations on molten metals by using the fused-silica pyrometer tubes which may be inserted right into the metal, the tubes being so thin that very little time is lost in the heating of the thermocouple to the temperature of the melt.

But this new and comparatively cheap fused quartz will undoubtedly also find much favor for many other purposes, for instance, in form of crucibles, bed-plates for muffle furnaces, etc., for which purposes fused quartz has distinct advantages.

New Balance.

The following illustration shows a new quick-acting, short-beam and highly sensitive analytical balance for scientific use, just placed on the market by Messrs. Voland & Sons, of New Rochelle, N. Y. It embodies all the latest improvements which have been introduced by this firm in their twenty years of experience in the design of analytical balances.

The balance is mounted in a French polished mahogany glass case with front counterpoised sliding-frame and glass top. In the illustration the front and rear frames are removed



SCIENTIFIC-ANALYTICAL BALANCE.

to permit a better view. The case is 21 inches long, 20 inches high and 10 inches wide.

The beam of the balance is 8½ inches long and is divided into 100 parts on either side. The beam is of truss construction and is made of hard metal of the manufacturers' own composition. The rider has a clean sweep over the beam and can be used from the zero point. The knife edges are made either of agate or steel. All bearings are of agate.

The pans measure 4 inches in diameter and the balance is sensitive to 0.1 milligram, with its full capacity of 500 grams in each pan, and it may be said that this rating is quite conservative.

Notes.

New York Section American Electrochemical Society.—At a meeting held on Jan. 30, at the Chemists' Club, Mr. Woolsey McA. Johnson, metallurgist of the Tri-Bullion Smelting Co. presented a very interesting paper on the electrometallurgy of zinc. Besides electrostatic and electromagnetic methods of concentration he covered the possibilities of both electrolytic and electric furnace methods for zinc production. The paper was a very able and conservative statement of the present situation, and was discussed at length by a number of experts in zinc metallurgy. We hope to give a more extended review both of the paper and of the discussion in our next issue. At the next meeting, to be held on Feb. 26, Prof. C. E. Lucke, of Columbia University, will lecture on the relative cost of power from water, steam, gas and oil.

Gas Producers.—A large order for gas producers was awarded to the Wellman-Seaver-Morgan Co., of Cleveland, by the United States Steel Corporation. It calls for 64 Hughes mechanically-poked continuous gas producers for their Duquesne steel works. These producers are to be operated by electric motors, and are equal in gas producing capacity to 160 hand-poked producers. The chief advantages claimed for the Hughes mechanical producer are that they save the labor of hand poking, give a better quality and a more uniform supply of gas, and in battery require less room than the hand-poked type of producer.

Tantalum.—While the tantalum lamp of the Siemens & Halske Co.—the appearance of which not yet two years ago marked such an important advance in electric incandescent lighting—is apparently already beaten by the new tungsten lamp, new applications are being found for tantalum. According to *The Engineer* (London) Siemens & Halske intend

to manufacture tools and other articles out of tantalum alloys, and the German patent, No. 167,217, granted to this firm, means perhaps the end of an extensive, and since the twentieth year of the last century, vigorous industry. The tantalum pen is said to have a great resistance against chemicals, to be much harder and more elastic than the steel pen, and on account of this hardness and elasticity to be indestructible. It exceeds in elasticity the well-known gold nib of the fountain pen, and so these two kinds of writing pens will soon be supplanted, if they succeed in manufacturing tantalum metal at an acceptable price. The fundamental patent of von Bolton for making pure tantalum metal in the electric furnace was noticed on page 238 of our Vol. IV.

The Frederick Pearce Co., 18 Rose Street, New York City, who purchased, about a year ago, the business carried on by the Willyoung & Gibson Co., have now provided the requisite facilities in the way of space and equipment for the progressive development of electric measuring and scientific measuring instruments. This company will also pay special attention to X-ray and electrotherapeutic apparatus.

Metallic Manganese.—Messrs. Geo. G. Blackwell, Sons & Co., of Liverpool, announce that after experimenting for two years they have developed a new method of producing a high-percentage metallic manganese, which they are in a position to place on the market at a comparatively low price.

Ferro-Alloys.—The Electrometallurgical Co. has been formed for the purpose of manufacturing ferro-alloys, and for the present time especially low-carbon ferro-alloys like ferro-chrome, etc. The interests of the company are closely identified with those of the Union Carbide Co. The manufacture will be carried out at Niagara Falls.

Ferro-Titanium.—The Titanium Manufacturing Co., backed by prominent New York capitalists, has bought a piece of property at Niagara Falls covering 4 acres. Electric power will be obtained from the Ontario Power Co. The object is the manufacture of ferro-titanium. The company is presumably the outcome of the researches of Mr. Rossi.

Maps of Niagara Power Districts. We have received from the Ontario Power Co., of Niagara Falls, maps of their power districts in a handsome cloth folder. There are five maps. No. 1 is a general map of the transmission lines of the Ontario Power Co., from Syracuse, N. Y., to Hamilton, Ont., and to Buffalo, N. Y.; it also shows the proposed extensions. No. 2, referring to Eastern Ontario and Western New York, is a general map of the Niagara frontier. No. 3 is a map of the Welland Canal; No. 4 of Niagara Falls and vicinity; No. 5 of Buffalo, Depew and West Seneca.

Enamelled Iron Pans.—The Stuart & Peterson Co., of Burlington, N. J., have placed on the market a line of oblong evaporating pans for chemists' use. These pans are of porcelain-lined iron with a raised edge to protect the porcelain. They are manufactured in three sizes, from 29 to 36 inches in length by 20 to 27 inches in width, with depths ranging from 2⅛ inches to 4 inches. They are particularly adaptable for drying chemicals in works and laboratories. When desired the pans are provided with heavy iron stands

Gas Producer.—Circular No. GP-1 of the Wellman Seaver-Morgan Co. gives a fully illustrated description of the Hughes continuous gas producer.

The Western Electric Co. has recently issued a well illustrated pamphlet describing their Hawthorne works for the manufacture of power apparatus, at the extreme west of the city of Chicago.

The Forter-Miller Engineering Co., of Pittsburg, have sent us their large catalogue of special apparatus and machinery for iron and steel plants. It includes concise descriptions of the Forter water-seal gas producer, the Forter feeding device for gas producers, the Forter charging machine for annealing furnaces, several types of Forter reversing valves, various types of welding furnaces, billet furnaces, annealing furnaces, crucible furnaces, open-hearth furnaces, blast furnaces, etc. All descriptions are illustrated by very clear diagrammatic drawings showing the principles of the design.

Pyrometers.—The latest catalogue of Messrs. Edward Brown & Son, 311 Walnut Street, Philadelphia, is specially interesting for the large amount of useful information on various types of pyrometers and their uses in the industries, especially in iron and steel plants, coke ovens and gas works, glass plants, brick, clay and emery-wheel works and chemical factories. Not only the manufacturers' own well-known hot-blast pyrometer, quick-acting platinum pyrometer, water-current pyrometer, etc., are described and illustrated, but the catalogue covers also the important types of other inventors, like electric resistance pyrometers, the Le Chatelier thermo-electric pyrometer, the Siemens water pyrometer, the Féry radiation pyrometer, the Uehling pneumatic pyrometer and others. The catalogue is concluded by illustrated descriptions of revolution indicators, pressure gauges, etc.

Fans.—Catalogue 200 of the American Blower Co., of Detroit, Mich., deals with their disc fans for all ventilating purposes.

Calendars.—The 1907 calendar of the National Carbon Co., of Cleveland, Ohio, has the picture of quite a pretty young lady, holding a mask in her hands, evidently as an excuse for the somewhat fantastic, but decidedly striking make-up of hair and dress. Between the calendar sheets of the different months descriptive sheets are inserted, dealing with various products of this company, as primary cells, dry cells, carbon brushes, arc lamp carbons, etc. The 1907 calendar of the Laclede Fire Brick Manufacturing Co., of St. Louis, is a third revised and enlarged edition of their well-known picture symphony on Satan's furnace equipment. It reminds the writer of a recent visit to a smelting plant, where Laclede firebrick was used very successfully and to a large extent. Somebody remarked there, and the others consented, that it was surely hot enough to make any man pious. We hope that the Laclede Co.'s calendar, besides its value as an advertisement of their goods, will have the same effect.

Welding of Iron.—The American Ferrofix Brazing Co., of Philadelphia, announce that they have secured the general sales agency for the Harris Calorific Co., of Philadelphia, manufacturers of apparatus for brazing and welding by means of the blow-pipe. As special advantages of this method in its latest improvements by the Harris Calorific Co., it is stated that flaws, imperfections, sand holes and cracks in castings can be perfectly filled in without the objectionable hard scale formed by the electric arc. Lugs and projections can be welded on more securely and economically than by riveting, and, when used in conjunction with "Ferrofix" the brazing of cast iron can be accomplished in an eminently satisfactory manner. The apparatus is extremely simple in construction, and does not require such skilled attention, nor consume such an amount of power as the electric arc

Carbon Tetrachloride and Sulphur Chloride.—Electrolysis of common salt yields caustic soda and chlorine. Caustic soda is sold at a good price, while there is some difficulty in working up the chlorine into commercial products which bring a good price. It is mostly worked into bleaching powder, but the supply having been larger rather than the demand, there has not been much profit in its manufacture in recent years. Naturally attention was directed to the manufacture of other chlorine products, and it is known that among others the Acker Process Co., in Niagara Falls, have made extended researches in this direction. Two of their main chlorine products are carbon tetrachloride and sulphur chloride. From announcements of the National Aniline & Chemical Co., 100 William Street, New York City who are selling agents of the Acker Process Co., we gather the following notes: Carbon tetrachloride is an excellent solvent, and dissolves oils, fats,

and innumerable other products. It is not acted upon by either strong acids or alkali. Carbon tetrachloride, as an extracting medium, has found wide application in the extraction of fats and oils from oil seeds, oil cake, animal tankage, wool, wool and cotton waste and other oil and fat-bearing materials. They are extracted by carbon tetrachloride with the highest degree of purity, absolutely free from residual solvent and contaminating odor, taste or "chemical smell," and the extracted materials may be produced absolutely free from solvent and with no odor or taste imparted to them. It is a very excellent cleansing agent, as it does not affect in the least the most delicate colors or fabrics, lace, feathers, silk, wool, cotton, etc., and the most delicate shades of silk, satin, etc., are not affected in the slightest degree when carbon tetrachloride is properly applied. It is, therefore, of peculiar interest for dry cleaning and cleansing establishments, who have heretofore used naptha and benzine. Its remarkable solvent properties make it an extremely valuable constituent in rubber and gutta percha cement and in the rubber and gutta percha industries, likewise in the lacquer, varnish and paint remover industries, and for other similar and innumerable purposes. A carbon tetrachloride solution of sulphur chloride is a vulcanizing agent of great value. Chloride of sulphur is a yellowish red, oily liquid, having a specific gravity of 1,709, and mixes in all proportions with carbon tetrachloride, benzole, carbon disulphide, etc., also with petroleum or naptha. It is used in the cold or dip process of vulcanizing rubber, in the preparation of rubber substitutes, artificial drying oils substitutes from Menhaden, and fish oils, corn oil, etc.; for the thickening of oils, rapid manufacture of printers' ink, etc.

Personal.

Mr. M. U. Schoop, the well-known European storage battery expert and electrochemical engineer, will arrive in this country on the steamship "Amerika," of the Hamburg-American Line, which is due in New York on Feb. 8. As noticed on page 338 of our issue of last August, Mr. Schoop has recently invented a simple practical method of autogenous welding of aluminium.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington D. C.

Carborundum.

No. 560,291, May 19, 1896, E. G. Acheson, of Monongahela City, Pa.

This patent describes an electric furnace, with modifications, for the production of carborundum in accordance with the general process of patent No. 494,767. The furnace is provided with a core, through which the electric current passes and to which it is largely restricted, the charge mixture being arranged in the furnace to receive its heat from the core in lines diverging from the direction of the path of the electric current, that is, as shown, around or upon the core, in contradistinction to those furnaces in which the charge is mixed with an electrically-conductive material. The core, while offering more or less resistance to the flow of the electric current, so that it will become sufficiently heated, is of lower resistance than the charge, so that little if any of the current shunts from the core through the charge.

The various furnaces illustrated each comprise a bottom and side and end walls of fire-brick, the side walls being laid up with loose joints to permit the free escape of gases, which burn at the points of escape and contribute to the heating of the charge. The two electrodes pass through the end walls, and each may consist of a number of spaced carbon rods, passing through openings lined with asbestos and connected externally by a terminal plate, or a single plate or block of carbon, or preferably of a number of rectangular carbon bars, clamped together by a metal frame into a rectangular mass, practically filling the end of the furnace. Copper plates are placed between the outer ends of the cars and have terminal lugs, which are clamped together and connected with the electric main. The core may be a solid mass, but preferably consists of granular carbon, the sizes of the grains depending on the size of the furnace and the electric current used. In a furnace having a core 8 feet long and employing 100,000 watts, the core is preferably 10 inches in diameter, and consists of grains three-sixteenths of an inch in diameter, of coked bituminous coal. The form and electrical conductivity of the grains are changed by use so that it is desirable to form other cores, when constructed of these altered grains, of a smaller diameter than the original core. The size of the particles constituting the ends of the core is preferably less than in the body of the core, to effect more intimate contact with the electrodes. To assist in maintaining contact between the core and electrodes, weights may be placed on the ends of the core, that is, on the bodies of fine particles filling the spaces between the ends of the core and the electrodes and extending up to the top of the furnace. Or the core may lie upon a lining of fire-clay on the bottom of the furnace, the ends of the core then being compressed by the weight of the body of charge material above. The preferred charge consists of a mixture of carbonaceous, siliceous and fluxing materials, plus a substance which will add to the electrical resistance of the mass, render it more porous and aid in the escape of gases, specifically, by weight, 20 parts of finely divided coal or coke, 29 parts of sand, 5 parts of common salt and 2 parts of sawdust. These materials are intimately mixed, and are packed in the furnace so as to surround or cover the core practically throughout its length. The charge is generally placed directly in contact with the core, but layers of paper may be interposed. It is advantageous to use in the charge, as a source of carbon, a hydro-carbon, such as anthracite coal, the products of distillation of which act as a fuel to assist in heating the charge. The core forms the necessary groundwork for the growth of the crystals of carborundum, which are formed in a ring around the core, the original constituents of the charge disappearing as this ring increases in diameter. Shunting of the electric current from the core through the charge is detrimental to the production of the crystalline product. The heating of the charge is assisted by the combustion, not only of the gases distilled from the charge, but, to some extent, by the combustion of the carbon in that portion of the charge exposed to the air.

No. 650,234, May 22, 1900, F. A. J. Fitzgerald, of Niagara Falls, N. Y.

Carborundum is produced in the electric furnace in masses of coherent crystals of insufficient solidity for use in the arts, since the crystals occupy approximately the same space as the original charge, over 60 per cent of which disappears as gas or vapor. The crystals being of higher specific gravity than the charge, the masses are necessarily porous and loosely knit together. For use it is necessary to separate the loosely-held grains, add clay or other binder, and fire. The clay binder detracts from the value of the molded articles when intended for purposes exposing them to high temperatures.

The improved method of producing coherent masses of carborundum consists in mixing carborundum in grains or powder of proper size with a temporary binder, for example, thin glue, molding into shape and heating the molded mass in an electric furnace to about the temperature originally used to produce the carborundum. The carborundum then recrystalizes and the product is a very hard, dense mass, occupying substantially the same space as before forming, without substantial loss of material by volatilization, except that of the temporary binder. Refractory bricks, crucibles or abrasive products may be thus produced, consisting of practically nothing but carborundum. When a product having electric conductivity is desired, a mixture of graphite, 15 to 20 parts, and carborundum, 85 to 80 parts, or other proportions, may be used.

Electrochemical and Metallurgical Industry

VOL. V. NEW YORK, MARCH, 1907. No. 3.

Electrochemical and Metallurgical Industry

With which is Incorporated Iron and Steel Magazine

Published on the first of each month by the
ELECTROCHEMICAL PUBLISHING COMPANY,
[Incorporated.]
114-118 LIBERTY STREET, NEW YORK.

J. W. RICHARDS, PH. D. ..... *President*
E. F. ROEBER, PH. D. ..... *Editor*

Subscription Price: $2 per year, postpaid to any part of the world. Single copies 25 cents.

Copyrighted, 1907, by the Electrochemical Publishing Co.

Entered as Second-Class Matter, June, 1903, at the Post-Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, MARCH, 1907.

CONTENTS.

EDITORIAL 71
Mors Imperatrix 71
Immigrants as Imports 71
The Metal Market 72
Utilization of Atmospheric Nitrogen 72
The American Workman 73
Chemists' Building 74
The Iron and Steel Market 74
CORRESPONDENCE:
Electric Smelting for the Foundry. By P. McN. Bennie 75
Melting Points. By F. Maeulen 76
Fixation of Atmospheric Nitrogen. By G. Erlwein 77
Metallurgical Calculations. (Thermal Efficiency of Open Hearth Furnaces.) By J. W. Richards 79
Electrometallurgy of Zinc. By W. McA. Johnson 83
Iron and Steel from Black Sands. By D. T. Day and R. H. Richards 85
The Butters Slime-Filter at the Cyanide Plant of the Combination Mines Co. By M. R. Lamb 88
The Electric Furnace in the Pottery Industries. By R. S. Hutton. 90
Electrochemical Problems 92
Electric Steel. (Induction Furnace.) By H. Roechling 92
NOTES ON ELECTROCHEMISTRY AND METALLURGY IN GREAT BRITAIN. 94
RECENT METALLURGICAL PATENTS 96
SYNOPSIS OF PERIODICAL LITERATURE 98
ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS 102
New Factory Building 105
Slime Concentrator 105
NOTES 106
PERSONAL 108
DIGEST OF UNITED STATES PATENTS. (Carborundum) 108
NEW BOOKS 109
BOOK REVIEWS:
Monographs in Applied Electrochemistry, Vols. 18 to 21 109
W. R. Ingalls, on Lead Smelting and Refining 110
Van Nostrand's Chemical Annual 110
M. Toch, on Mixed Paints 111

Mors Imperatrix

During the month of February death has removed three eminent veteran fighters from the front ranks of chemical endeavor and activity: the Russian, Dmitri Ivanovitch Mendeleeff; the Dutchman, Hendrik Willem Bakhuis Roozeboom, and the Frenchman, Henri Moissan. The death of each of these three men has been deeply felt as an international loss to chemistry. Mendeleeff's name will forever be connected with the periodic system of elements for which he built a broad, sound, general, empirical foundation. Roozeboom highly distinguished himself in chemical thermodynamics, in continuing and expanding the work of our late J. Willard Gibbs. As Prof. Bancroft once put it, what was condensed into a few paragraphs by Gibbs has been expanded into the phase rule by Roozeboom, and bids fair to become the basis of classification for the whole of chemical science. Moissan had only recently been honored with the Noble prize for chemistry. He is known personally to many American chemists from two visits to this country. But his life work with the electric furnace is known all over the world wherever there are electrochemists. We hope to publish in our next issue a sketch of his life and work from the pen of one who has the privilege to call Moissan his teacher and master. While we mourn the loss of these three men we know that their work is alive and will be alive. Each of these men opened new avenues for chemical progress. Future generations will harvest the fruit.

Immigrants as Imports

Approximately a million immigrants entered the United States last year. These were a heterogeneous lot as regards race, color and previous condition of cleanliness. They were largely adult males in the prime of life—mostly young men at the age of maximum productivity. They were distinguished by the boldness and the enterprise of the pioneer. The same outcry which was made by the older immigrants and their descendants, that these new ones are the "scum of Europe," was made by the Americans of English descent seventy years ago against the Irish and German immigrants of that period. We thus will dismiss that indictment. Let us then consider the economic value to the nation of these as producing units for the industrial machine. It would cost on the average at least three thousand dollars with interest charges to raise each of these human beings in America. That this is a conservative value can be seen by comparing this figure with the price of black slaves and their productivity in ante-bellum days. Consequently, the net increase of the nation's wealth due to this class of imports, totals the immense sum of three billion dollars per annum, or is about equal to our entire foreign trade.

both experts and imports. This valuation is probably too low. Very little is paid for this importation, but it is simply taken from the older countries by the will of the immigrants. We hope that each of those million as read this will not be offended by being classified as "duty-free" imports. Whoever of us can console himself that America was colonized by immigrants, who came in duty free.

The Metal Markets

The upward swing of the pendulum has carried the price of metals to an undreamed of high level. Copper, due to the immediate causes outlined in our notes on car shortage in our January issue has risen to full 25 cents, and the copper supplies are so closely held that if large producers so desired copper would go to 28 or 30 cents. Pig iron is selling so high that importations of Scotch iron are being made. Lead is absolutely controlled marketwise by the dominant interests. Silver is low relative to prices before 1893, but has risen nearly 40 per cent over panic prices. There seems to be good reason for looking for a healthy recession. Too high prices curtail consumption and also teach the use of cheaper substitutes to the trades. The capital cost of all new constructions is now charged to succeeding generations at a figure that is so high that the railways and industrial companies wisely are planning to curtail new work. Spelter is selling relatively high, but based on cost of production its price is low as compared with copper, lead and iron. This is due to the fact that the zinc business has not yet been "trustified." Due to high price of lumber, with which galvanized iron competes, and high price of copper with which sheet zinc and galvanized sheets also compete, when the reaction comes hard, spelter is less apt to feel the downward force than other metals.

* * *

It would appear that the recession in business—slight though it may now appear, and to some observers only confined to the stock market—is liable to grow greater. First of all, next year is a presidential year, and supersensitive finance discounts all uncertainty a long time in advance. Then too—car shortage and lack of railway facilities, of which Mr. J. J. Hill has spoken so clearly—hamper expansion. Undoubtedly good crops next Summer would diminish the intensity of the reaction. Considering the present high levels of metals in relation to this tendency for business to draw in its horns because of high prices, we would infer that consumption will not increase, or in other words, relatively be decreased, and normal rate of growth be reduced. The near increase of metal production, due to starting up of new metallurgical works, will increase absolutely the production, consequently lower prices for metals during the Winter of the year 1907-1908 seem probable. This will be an unmixed blessing, for growth has been too rapid to be altogether healthy. There is no great apprehension of a real serious panic, but such a slowing down will do us good and allow plans to mature. As the French say, it is a case of "reculer pour mieux sauter"—to draw back in order to get a running jump. In the long run, no sane man can help but be a bull on American industry.

Utilization of Atmospheric Nitrogen

The free nitrogen gas, which makes up 75 per cent by weight of the atmosphere, is useless in its inert state. Its chief characteristic property is its unwillingness of entering into any combination under ordinary conditions, and to make it useful we must force it into combination. While the numerous practical attempts in this field have been closely followed and discussed in this journal in the past in numerous articles and notes, the paper by Dr. Georg Erlwein, published elsewhere in the present issue, contains much interesting information that is new, and affords a welcome opportunity to comment again on the matter. Dr. Erlwein is the chief engineer of the electrochemical department of the Siemens & Halske Co., and his paper is interesting *per se* as a human document, showing the enormous amount of early research work done by this company along lines completely neglected at that time by others, and emphasizing again the eminent personal qualities of the late Werner Siemens. He conceived the idea that the day would come when agriculture would cease to provide food for the human race, and artificial food would be made in industrial plants. This would be, of course, the natural solution of the social problem of to-day, of which Secretary Shaw recently spoke before the students of the University of Chicago, when he pointed to the number of immigrants which come to this country every year, not to go to the farms, but to the factories—and "the time is coming when manufacturers will outgrow the country." The evolution now going on tends to replace an agricultural State by an industrial State. This economical "reaction" cannot go on to a finish, except the idea of industrially produced artificial food is realized. Otherwise, according to the laws of social economy (which are quite analogous here to those of chemical dynamics), the reaction will stop before it is finished and a state of equilibrium will be reached. The late Werner Siemens, in spite of his highly developed faculty of prophetic imagination, was an eminently practical man. He investigated experimentally the possibilities of artificial food, but his company's larger-scale commercial work in this field tended to the solution of the simpler and nearer problem—the production of fertilizers from the nitrogen of the air. Dr. Erlwein's story of the numerous attempts taken up and given up in succession is an interesting object lesson on the methods by which the former artillery lieutenant, Siemens, starting with nothing but his brains and his energy, succeeded in building up the wonderful industrial structure of the Siemens & Halske Co.

* * *

In our issue of last April we gave in an editorial a review of the various possibilities of fixation of atmospheric nitrogen. We will not repeat ourselves if we emphasize in this note some distinct features of only the two processes which have become a commercial success. One, the Birkeland-Eyde process, in use in Norway, produces nitric acid and nitrates direct from atmospheric air by means of electric discharges. The raw product—the atmospheric air—costs nothing. The two chief items of cost are the electric power for the discharges and the cost of concentrating the end product of the electrochemical discharges—a very dilute solution—into a marketable product. To understand the commercial success of the Norwegian plant, it is necessary to consider its extremely low cost of electrical

power, which is given as $5.00 or less per electric horse-power-year. The other commercially successful process, in use in Italy, produces calcium cyanamide either from calcium carbide and atmospheric nitrogen or from lime, coke and atmospheric nitrogen. Without taking into consideration the cost of lime and coke, it is important to understand that atmospheric nitrogen, not atmospheric air, is here the raw material. In other words, it is first necessary to separate the nitrogen from the oxygen of the air. Thus we have here a considerable item of expense right at the start of the process. On the other hand, the end product—cyanamide—is directly marketable or may be easily worked up into other marketable products. With respect to the latter point, Dr. Erlwein's paper is very suggestive.

* * *

As already noticed there are two methods of making cyanamide. The Erlwein (Siemens & Halske) process starts with lime, coke and nitrogen, and produces directly cyanamide in an electric furnace. In the other process this reaction is resolved into two steps: first, calcium carbide is made in the electric furnace in the ordinary way, and then, according to the method of Frank, the carbide is changed in an atmosphere of nitrogen into cyanamide. As long as the calcium carbide boom with high prices lasted in Europe, the Erlwein process was more profitable. When the boom was over and the carbide prices went down, the Frank process became the cheaper one, and is now used in Italy. An abstract of a research of Carlson in the Synopsis of our present issue seems to indicate that the last word has not yet been spoken as to the best method of making cyanamide. As operated in Italy, the Frank process is a most interesting example of the commercial possibilties of using extreme temperatures. The raw materials are, on one hand, nitrogen, obtained by fractional distillation from liquid air—thus necessitating the lowest temperatures now available—and on the other hand, calcium carbide—the commercial product of the electric furnace with its temperature at the other end of the temperature scale.

The American Workman

There are four factors in the production of wealth—land, capital, labor and management. In our November issue we editorially discussed some of the characteristics of the American capitalist. We may now take up the salient features of the American workingman, with whom the capitalist is so often at variance. First of all, let it be said that in all that makes for social and economic well being, the laborer in the United States, be he skilled or unskilled, has as much as or more than the average middle class in Europe. While his opportunities for pleasure are not so good, yet this is more than counterbalanced by material enjoyments and by the hope and ambition that he and his family can better their station. This is due to the wonderful productivity of American industry in which so large wages are paid because of the widespread use of machinery. The food of our average laborer is of so high a class that his physical strength is great. Often lean and angular, his endurance is wonderful. The American laborer is also resourceful and ingenious, a result of the pioneer spirit that still exists to-day in the descendants, spiritual as well as physical, of the founders of the republic. The readiness with which the American adapts himself to new conditions is seen in the way in which the large blast furnaces in the metallurgy of copper and iron are handled. The ability to operate expensive machinery at a maximum efficiency is par excellence the cause of high wages. As we have often pointed out, the effect is that the labor charge per ton of product is usually much less in this country of high wages than in countries of low wages, like Italy.

* * *

A further distinguishing trait is the kind treatment that the American workman gives his wife and family. This always strikes the acute foreign observer, and should be a point of pride with all of us. The American always wants his children to have the advantages that he missed. This is as it should be in a nation of self-respecting freemen. In loyalty to the employer the American is not behind the European, though this is less formal than in Europe where the feudal instinct is everywhere manifest. The rise of labor unionism in this country is giving some of us much anxiety, but it is a natural development of the workman, where he feels that his rights are withheld. Should the "ca-canny" spirit pervade America as it has England, it will be a sad day for all of us. Let it be distinctly understood that combination of workmen is an absolute necessity, where the spirit of rapacity is rampant on the other side. But to go to the other extreme and to wrest from capital its rightful return by the aggression and tyranny of labor unions, will put a blight on all industry. However, the labor question looks less serious to us now than it did four years ago, before President Roosevelt took up his active campaign of the "square deal." And we believe that the good sense of the American people, making itself known in forceful public opinion, will tend to minimize the errors of thoughtless and selfish men whether they wear overalls or sit at mahogany desks.

* * *

The American workman is to be criticised in two respects. He is often headstrong and restless in leaving employment, but this only reflects the spirit of twentieth-century America. In the second place too many American workmen are wasteful in their household expenditures, especially in the purchase of foolish nicknacks. This is also due to the crude spirit of eternal youth, especially rampant in the growing West. We have not the slightest doubt that a general system of national postal savings banks would extend the spirit of thrift and savings, so prevalent in careful New England and the other Eastern States, and increase the wealth of the country beyond all measure. The waste of the poor is the curse and cause of their poverty. But considering the American workman in a composite mental photograph, we are rather proud of him. As far as happiness and morality goes he is ahead of his wiser, far-seeing, and avaricious capitalistic friend, but, of course, he does not stop to realize this. If his employer be of the higher type, both give each other full measure of affection, sympathy and loyalty. And these isolated examples of perfect accord between the "boss and his boys" are not growing less, even in these days of monster corporations.

Chemists Building

At a special meeting of the building committee of the Chemists' Club on Jan 18, the president, Mr Maximilian Toch, presented the following report as to a new building for the Chemists' Club.

"1 A stock company should be formed whose directors would have exclusive control of the building after erection, and they should enter into a lease on very reasonable terms with the Chemists' Club for such space as it may require for meeting room, library and social purposes. The Chemists' Club shall have the right to sub-let the meeting room under similar conditions as they sub-let rooms now at 108 West Fifty-fifth street, and suitable restrictions should be placed upon the Chemists' Club so that only scientific, musical and kindred societies may become sub-tenants.

"2 This stock company shall be a realty company, which shall be composed of the principal men who have contributed, the president being the chairman of the board, and absolute control of the entire building shall be vested in this board.

"3. The management of the building shall be entirely in the hands of the directors of the realty company * * * *

"4 Any surplus funds, after the payment of the dividends, should be used for the purpose of outstanding stock of the corporations. * * * *

"5. It shall be the privilege of the Chemists' Club while a tenant of the building to purchase stock at par, the same conditions mentioned in paragraph 3 should obtain."

The building shall be so constructed that there will be at least ten laboratories to let to chemists. There also shall be ten or fifteen sleeping apartments for non-resident members, while the library, which shall be known as the Perkin library, shall have all books, etc., in duplicates, one copy for use at the club, the other for circulating purposes. Further, there will be baths, a bowling alley and a small gymnasium, for all of which a nominal fee will be charged. A large hall with a suitable lecture table will be provided, capable of holding comfortably 500 people.

The Iron and Steel Market.

It is clear that the crest has been passed in the iron and steel trade The market is on so different a basis than formerly that this statement does not infer what it would have been a few years ago, that prices were becoming weaker and production decreasing. Prices of all finished steel products are as firm as they were a month or two months ago, and in some few instances they are higher. If production has decreased at all, the change is of the slightest and has been forced purely by physical conditions Pig iron prices have receded but a trifle, but considering the prospects for six or nine months to come they are remarkably firm.

The steel producers have an unprecedentedly large volume of business on books, and a very large part of this is in the form of absolute orders and specifications This business is of the soundest description, and will be filled as fast as physical conditions permit, with the sole exception that the large steel mills will not buy merchant pig iron to swell their production of crude steel and finished products, to the extent they probably would were it certain that the present orders would be replaced by equally large ones at full prices. The exception is a slight one as to tonnage, but illustrates an important phase of their attitude. There is some profit in furnishing finished steel products made from purchased pig iron, but very much less than in using the steel producer's own material.

It is accepted that railroad buying in the future will be on a materially reduced scale, on account of the difficulty in financing, but the present commitments of the railroads will keep the iron trade at full speed for many months to come. Commitments from interests other than the railroads are proportionately heavier than usual, and their renewal will depend largely upon crop prospects.

The indications thus are, that while the greatest activity should prevail for six or nine months to come, there will be some recession in demand late this year and in 1908. Productive capacity, however, is increasing rapidly.

It taxed the resources of the industry to make 17,821,307 gross tons of pig iron. In the following year, owing to the completion of new furnaces, a much larger tonnage could have been made, but the slump in production in the last quarter of the year brought the total to only 18,009,252 tons. In the following year demand was light and many new furnaces which had been completed were not blown in until about the close of the year, the 1904 production being only 16,497,033 tons. In 1905 the full employment of all capacity resulted in a production of 22,992,380 tons, while 1906 showed 25,307,191 tons. Through the progress of new erection it can be estimated, on quite complete data, that so far as physical considerations control, a production of 28,000,000 tons can be made. With the present trade outlook it is quite certain that no such tonnage can be absorbed, and a reaction in prices of pig iron is inevitable. It does not follow that a reaction in prices of finished steel products is probable, for the double reason that pig iron had reached a level out of all proportion with finished products, and prices of finished steel products are closely held. They were prevented from unduly advancing, and can within limits, be prevented from declining.

The following table represents approximately the production of the absolutely new furnaces blown in, or to be blown in, from Jan. 1, 1905, to July 1, 1907. The furnaces included are all absolutely new ones, with the single exception of a southern furnace, which replaces an old one not in blast since 1903. Many furnaces have been rebuilt, but it is not regarded as feasible or desirable to include them:

PRODUCTION OF NEW BLAST FURNACES,

	Production During					
Blown in during	*1st Half,* 1905.	*2d Half,* 1905.	*1st Half,* 1906.	*2d Half,* 1906.	*1st Half,* 1907.	*2d IIalf,* 1907.
First half, 1905	338,000	487,000	487,000	487,000	487,000	487,000
Second half, 1905	.....	119,000	256,250	256,250	256,250	156,250
First half, 1906	.....	.....	185,000	440,000	440,000	440,000
Second half, 1906	.....	.....	.....	119,000	235,000	235,000
First half 1907	.....	.....	.....	.....	490,000	802,500
Totals	338,000	606,000	928,250	1,302,250	1,908,250	2,120,750
Actual production	11,163,175	11,829,205	12,582,250	12,724,941	.....	.....

The actual increase in production in the second half of 1905 and the first half of 1906 was progressively greater than the contribution of the new furnaces. This was due chiefly to harder driving and the rebuilding and otherwise improving of old furnaces. No such influence was manifest in the second half of 1906. Possibly the limit of hard driving had been reached: certainly weather conditions were especially unfavorable, and an unusually large number of furnaces were out for relining during the third quarter of the year.

The presentation should be conclusive that a very large in-

crease in production is possible over 1906, while trade conditions do not warrant the belief that there will be any material increase in consumptive demand.

PIG IRON.

The Bessemer pig iron is greatly disturbed and the outlook is quite uncertain. A large tonnage regularly goes from merchant furnaces to consumers on contracts which call for monthly adjustment of price, according to the average of sales made in the open market. These contracts contain a clause releasing the consumer from taking the iron should the monthly average pass above $20. This it did last October by a few cents, while the November average was but a few cents under $22 and the December and January averages were both $22.07 f. o. b. valley furnace. In December an adjustment was made with one consumer by the sale of a tonnage at a flat price considerably under the average. In January a round tonnage was released, which was sold to other parties. In February, adjustments were not so easily made and the whole future of such contracts is in doubt. The large steel interests which occasionally buy large tonnages in the open market completely withdrew from the market months ago, but for some time the market advanced through the very heavy purchases of malleable iron foundries and steel foundries. These interests depend largely on the railroads and their interest in the market is now slight, so that the merchant furnaces making steel making pig first, lost their regular customers and are now losing their newer customers. Bessemer pig for second half is held nominally at $21.50, valley furnace, but some small lots have sold at lower prices and it is purely a matter of conjecture what may be done later on large lots. Southern iron showed a reactionary tendency, but the chief producers have been endeavoring to hold strictly to the old quotation of $18.50, Birmingham, for second half. There is too little inquiry to test the market. Foundry iron f. o. b., valley furnace, has been nominally $21.50 for second half, but the market has not been tested. Altogether the demand for pig iron is so stagnant that close quotations cannot be given, and time must fix the new level, if there is to be one, as seems inevitable. Prices cannot for the present precede to former levels as costs to ordinary merchant furnaces are much higher, with the large advances in coke and ore.

STEEL.

The supply has been much better and steel mills have caught up, to a large extent, on old contracts. No billets or sheet bars are offered as originating in Pittsburg, but other steel works, and particularly new interests, have been offering steel at slight concessions. While two months ago Bessemer billets were nominally $29.50, f. o. b. Pittsburg, and sheet bars $30, f. o. b. Pittsburg, billets can be had f. o. b. Youngstown or Ohio valley mill at about $20, f. o. b. mill, and sheet bars at about $29.50, f. o. b. mill. To most consuming points this means a reduction, although for actual Pittsburg delivery it could hardly be said that there has been a decline.

FINISHED STEEL.

There have been no important changes in prices. Steel boiler tubes have been advanced two points, or about $4 a net ton, following an advance of one point Jan. 25, and of two points Dec. 20. Independent tin plate mills are obtaining an advance of 10 cents a box for third quarter deliveries, but the regular price has not changed. At regular mill prices plate deliveries are three months or more behind, steel bars two to three months and sheets two to three months behind. Occasionally premiums are obtained on these lines for early delivery, but in general buyers are so well covered by contracts that business is conducted at the regular mill prices. These are as follows:

Standard rails, 50 pounds and heavier, $28 at mill; light rails made from new steel, f. o. b. Pittsburg, $34 on carloads and $33 on larger lots, sections 25 to 45 pounds.

Structural shapes, $1.70 for beams and channels, 15 inch and under, angles and zees; $1.75 for tees; $1.80 for beams and channels over 15 inch.

Plates, $1.70 for tank quality, ¼ inch and heavier, 100 inches wide and less.

Merchant steel bars, $1.60 base.

Sheets, 28 gauge, black, $2.60; galvanized, $3.75.

Tin plates, $3.90 for 100-pound cokes.

CORRESPONDENCE

Electric Smelting for the Foundry.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—In the February issue of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, Dr. Richard Moldenke, the able secretary of the American Foundrymen's Association, writes a letter so full of suggestive hints that I commend it to the attention of every foundry manager. In Dr. Moldenke's letter the whole subject is brought to such a clear, definite focus that foundrymen and others interested in the intensive development of foundry practice may find plenty of food for reflection.

It is likely that the needs of the humble foundry have not had the attention they deserve from those of us who are trying to make a place for the electric furnace in the general metallurgical scheme. Nowadays the "tonnage" bug is very busy among our blast furnace and open-hearth brethern, and it may be we champions of the electric furnace have also fallen victims to the same influence.

Yet I do not think the possibilities of the electric furnace in the foundry have been entirely overlooked, for at a meeting of the Philadelphia Foundrymen's Association, on June 1, 1904, I had the honor of presenting a paper before that body on the "Application of the Electric Furnace to Metallurgy of Iron and Steel."

The paper covered generally the state of the art at that time, finally closing with the following for the benefit of that particular audience:

"In concluding this paper we take the liberty of making some reference to the application of the electric furnace to foundry practice, as being of more immediate interest to you. Take a foundry with a number of cupolas. It would be possible to arrange an electrical refining furnace so that it could use the product of any one, or all of the cupolas. The accompanying illustration (showing a furnace of the Héroult or Keller type) will give an idea of how this could be done, although several types of furnaces shown here could be applied. Here we have a furnace body in the form of a ladle, placed upon a carriage, suitably counter-balanced, and able to swing free in a circle. It may receive its charge and then be placed under the arrangement for carrying the electrodes, as shown. By lowering the electrodes, turning on the current, refining may be carried out as previously described in several processes. Without using excessive currents liquid iron may be converted into steel of good quality.

"This may suggest to some of your enterprising foundry managers ways of employing their full capacity at all times; to improve the quality of their castings; *to convert a portion of the product into steel*. For a small cost a foundry arranged for the manufacture of cast iron could undertake *steel castings*, and augment considerably its sphere of commercial activity.

"As to electrical power, many foundries are already equipped. However, in discussing the matter with a well known central station manager, we were assured that they would welcome any proposition which would take power during their periods of light load, say, from 10 P. M. to 1 P. M. the next day, and could make very low rates for such intermittent power to be taken at definite times. It would enable them to increase their

[illegible] factor and also fill up their pocketbooks at the same time."

It will be observed, however, that the method suggested above differs somewhat from the one proposed by Dr. Moldenke. I was referring then to a process taking hot metal from some fuel fired apparatus, and by means of the electric furnace doing sufficient refining to produce steel castings metal.

I think Dr. Moldenke is quite correct in his opinion that for such operations as are purely melting propositions, involving only a minimum amount of refining, the electric induction furnace is worthy of consideration. Given a proper quality of selected scrap it would be a comparatively simple process to turn out a metal very suitable for steel castings.

Until the experiments have actually been made and results studied, I am not prepared to say what economies will be realized. The conditions under which such operations would be conducted would, in many cases, be unique, as pointed out by Dr. Moldenke. For instance, take the case he mentions, where a foundryman finds it necessary in order to get a large contract to bid on a specification including some steel castings. In such cases the foundryman might feel warranted in using the electric furnace to produce his steel casting composition, so long as it cost less than he would have to pay for outside work. The simplicity of the installation would probably appeal to him also. In addition to the great advantage of being able, with the electric furnace, to get the highly fluid metal necessary for fine and intricate castings, there are the further advantages of control of temperature and atmosphere, points of vital importance for high-grade work.

Electric Furnaces in Brass Foundries.

When considering the use of the electric furnace for melting brass compositions, we come to a problem of quite a different character. The production of brass and allied mixtures is necessarily a *purely melting process*, and for the purpose it seems to me the electric induction furnace is admirably suited. Compared to simple melting of iron the conditions are quite different as to working temperature, resistivity and specific heat of the bath, etc. Yet there is the great advantage in favor of the induction furnace that it approaches very near to the conditions existing in the crucible process of melting brass, and for that reason should give the same superior quality of metal. Superior quality of metal generally means a higher price for the product.

As to the economy of the electric induction furnace compared with other methods, I think our data are as yet too meagre to permit of positive assertions. If we compare the crucible process with the induction furnace process I should say that there is hardly any doubt that brass mixtures can be melted in the induction furnace at less total cost per ton than in crucibles. If we compare the induction furnace with the more modern types of brass melting furnaces, then there is not so much room for fuel economy, if the published figures of 7 to 10 cents per 100 pounds melting cost are taken as a basis.

However, I believe the matter of loss of metal or "shrinkage" is of far greater importance, both as to cost and quality of metal; and in that respect the electric induction furnace possesses advantages quite peculiar to itself. Of course, the shrinkage loss varies greatly with different mixtures, running from 15 per cent down to as low as 2 per cent. If 5 per cent may be taken as a conservative mean, and 10 cents per pound as a fair estimate of value, then it is evident that there is a loss of about 50 cents per 100 pounds to work on.

Theoretically, the electric induction furnace should eliminate such losses to a large extent, by reason of several favorable conditions:

(1) There are no oxidizing gases playing directly on the bath of metal, as in most modern brass melting appliances.

(2) The heat is not conducted from some external source, as in crucibles, where the temperature is difficult of adjustment, frequently higher than is wanted and unfavorable to uniform results.

(3) The heat is generated directly within the mass of metal itself, and being under perfect control there is no occasion for overheating or loss of any of the constituents of the mixture by reason of lack of control of temperature.

(4) In the induction furnace the atmosphere may be so controlled as to always have reducing conditions, thus avoiding loss of metal by oxidation.

The complete elimination of shrinkage losses, or even a substantial reduction of such losses, offers even greater opportunity for economy than the item of fuel. There is every reason to expect that the induction furnace can be made the "clean, wasteless process" mentioned by Dr. Moldenke.

I do not believe I am committing a breach of confidence by saying that the possibilities of the electric induction furnace in these lines is fully appreciated by those working for its development, and that experiments to prove its value in the lines suggested above are now under way.

P. McN. Bennie.
FitzGerald & Bennie Laboratories, Niagara Falls, N. Y.
Feb. 23, 1907.

Melting Points.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—In your February, 1907, issue, on page 48, under "Melting Points of Elements," there is a table of melting points, the elements being arranged according to the periodic system. Under group VIII. there appears:

Ru.	Pd.	Rh.	Ag.
	1,900	1,520	962′

While this should read:

Ru.	Rh.	Pd.	Ag.
	1,900	1,520	962′

It may be of interest that while Dr. Harker has found the melting point of platinum to be 1,710° C. by methods thoroughly described in the *Proceedings* of the Royal Society, Vol. A76, 1905, the physicists in our Bureau of Standards at Washington have determined the melting point of platinum as 1,730° C.

The minus sign has evidently been omitted in the temperatures given for the solidification of oxygen and fluorine; sulphur should read 444.6 instead of 114° C., and tin 232 instead of 224° C.

In submitting these corrections it is not intended that they cover the whole table, as I am simply quoting from memory.

New York City. Frederick Maeulen.

[The table on page 48 of our last issue was reproduced by the photographic engraving process from the original table published in the London *Electrician*, to which journal due credit was given. The table is interesting not only on account of its arrangement but because it embodies the results of Dr. Harker's very extended researches in the (British) National Physical Laboratory. We are much obliged to Mr. Maeulen for the corrections given above, but may add that in the meantime some further and quite serious complications have arisen in the matter of establishing a reliable high-temperature scale on account of the publication of researches carried out by L. Holborn and S. Valentiner in the (German) Reichsanstalt. They claim that the fundamental former comparisons between the gas-thermometer and the thermocouple scales have not been as reliable as they were assumed to be. They now find 1,780° C. to be the melting point of platinum. This discrepancy is very much more serious than the difference quoted by Mr. Maeulen between the values of Harker and of our Bureau of Standards. The uncertainty of the whole situation is, however, clearly indicated by the fact that the Reichsanstalt will not make general official use of the new figures of its own members until the matter has been thoroughly cleared up by further researches.—Editor.]

Fixation of Atmospheric Nitrogen.

The fixation of atmospheric nitrogen and the application of the products thereby obtained was the subject of a very able paper presented some time ago before the Berlin Electrical Society, by Dr. Georg Erlwein, chief engineer of the electrochemical department of the Siemens & Halske Co. The author has been interested in work of this kind for his company for the last sixteen years.

His full paper may be found in the issues of Jan. 10 and 17, 1907, of *Elektrotechnische Zeitschrift* (pages 41 and 62). In the introduction some preliminary researches are briefly mentioned which were made by Werner von Siemens in 1889 in collaboration with A. W. von Hoffmann; further investigations by O. Frölich and G. Erlwein on the electric production of ammonium nitrate (German patent 85,103 of 1894). Neither of these investigations led to an industrial success, although both had been undertaken, not purely for research purposes, but with an industrial end in view.

The author then mentioned briefly the researches of Crookes and Lord Rayleigh, Bradley and Lovejoy, Birkeland, Kowalsky, Pauling, all of which have been fully covered in our columns. The author also named the following chemical

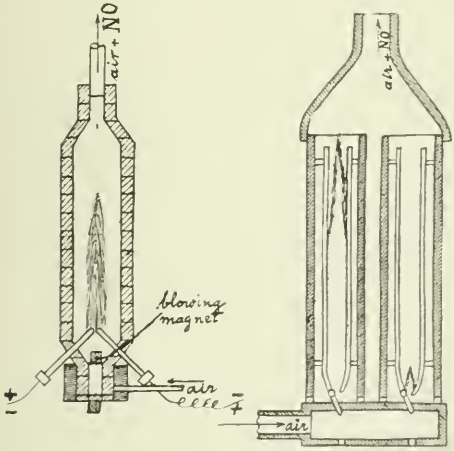


FIG. 1.—SIEMENS DEVICES FOR FIXATION OF ATMOSPHERIC NITROGEN.

manufacturing companies as having been or being interested in work of this nature: Salpetersaure Industrie Gesellschaft in Gelsenkirchen, Westdeutsche Thomasphosphat Werke, Badische Anilin-und Sodafabrik in Ludwigshafen.

Siemens & Halske took up the problem again in 1902. The starting point of their new researches was the experience which they had gained in the development of the flame arc lamp, in which the arc carbons are impregnated with certain salts, among them, salts of rare earths and fluorspar. When these salts evaporate into the arc the arc is lengthened and its zone of reaction becomes more effective. Under proper conditions of the experiment, including a blowing magnet acting on the arc and increasing its surface, the effect becomes surprising. The left-hand diagram of Fig. 1 shows the principle of the arrangement used by Siemens & Halske in 1902. In a cylindrical space supplied with compressed air, an arc is produced between impregnated thick carbon electrodes or cooled metallic electrodes and the surface of this arc is greatly increased by the use of a blowing magnet.

Later on, in 1904, a second method was tried by Siemens & Halske, based on the action of the horn lightning arrester so well known in Europe. The horn lightning arrester consists of two vertical horns, the lower ends of which are near together, while upwards the two horns diverge from each other more and more. The arc is formed, of course, between the two lower ends which are near together. It automatically travels upwards, is thereby enlarged in surface and is finally automatically broken. On this principle the discharge apparatus is based, shown at the right hand of Fig. 1. Between parallel or diverging vertical electrodes, which have a length of several meters and which are placed in closed porcelain or clay tubes, arcs are started at the bottom, which then travel upwards, continually increasing their surface and finally are broken, the speed being easily adjustable. Neither of these two methods has yet been developed into an industrial process which would be sufficiently cheap.

Some notes were given by the author on the efficiency of various systems employing electric discharges through air, and it was said that even with the best efficiencies now obtained, only 3 per cent of the electrical energy are utilized for the oxidation of the nitrogen or the formation of nitric acid proper, while the balance of 97 per cent is consumed mainly by heating the gases required for the reaction as well as the excess of air.

As to the commercial importance which may be attained in future by processes using electric discharges through air, Dr. Erlwein thinks we can give a definite answer only after the lapse of some more years.

A second group of processes is based on the facts known since Wöhler and Deville, that certain metals and metalloids, like silicon and boron, when heated with nitrogen, form nitrides and that these nitrides when treated with steam, again decompose with evolution of ammonia. Technical experiments in this direction on a larger scale have been made by Marguerite, Sourdeval, Mond and Solvay, and also by Friedrich Siemens who worked together with Dr. Obach on this subject at the end of the seventies in Dresden. Siemens' first experiments were not very encouraging, but they were useful in so far as they decided several questionable points.

The Siemens & Halske Co. took these researches up again in 1897 in connection with Dr. Mehner and Director Schlutius, of the Westdeutsche Thomasphosphat-Werke and later with the Gold-und Silber-Scheideanstalt in Frankfurt. Instead of boron nitride (employed in the original experiments) the nitrogen-compounds of sodium were employed, in the first place cyanides. These cyanides in the new experiments were equivalent to the nitrides in the older experiments in so far as they were not intended to be the final product, but were to be decomposed with overheated steam to yield ammonia.

In the old empty Grabau aluminium factory in Trotha, where a 500-hp. steam dynamo was available, a process was tried for considerable time, which had been patented by Dr. Mehner for manufacture of cyanide and ammonia. The process was based on older work of Mond. The results obtained were, however, not sufficiently promising from a commercial point of view. Cylindrical furnaces of 6 meters height and 1 meter diameter were used, which were charged with sodium carbonate and coke. By means of generator gas as source of nitrogen, it was intended to produce first cyanides and to decompose them then at a suitable place of the furnace by treatment with overheated steam so as to get ammonia. In the latter reaction sodium carbonate would be regenerated and was to be used over again together with coke for a new charge of the furnace. The gases of reaction which would be generated during the whole process, and which contained a very high percentage of carbon monoxide, were intended to be used in gas engines after the ammonia had been recovered in scrubbers.

A third group of processes is related to the manufacture of calcium carbide. The outcome of the work in this direction is the manufacture of calcium cyanamide, which is now commercially successful on a large scale. Dr. Erlwein gave an

historical review of the development of the process, mentioning the names Frank, Caro, Rothe, Pfleger, Freudenberg, Frank, Jr., Wagner, Gerlach, Erlwein. The Gold-und Silber-Scheideanstalt of Frankfurt (the leader of the cyanide syndicate) was first associated with Siemens & Halske in this work, but dropped out later on account of the weak cyanide market at the time of the Boer War. Siemens & Halske then decided not to interest themselves any longer at that time in the production of cyanide from cyanamide,* but to stop with the production of cyanamide and to sell it for fertilizing purposes.

Concerning the principles of making calcium cyanamide

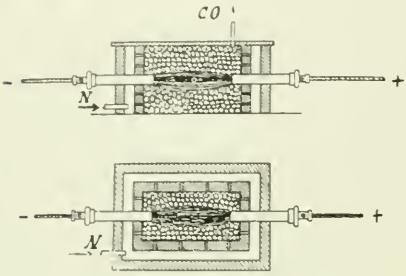


FIG. 2.—CYANAMIDE FURNACE.

either from calcium carbide and nitrogen (Frank-Caro process), or from lime, coke and nitrogen (Erlwein or Siemens-Halske process), reference must be made to former descriptions in our columns (for instance, our Vol. I., p. 423; Vol. IV., pp. 136, 327). The description of the furnaces, given in Dr Erlwein's paper, appears to contain, however, information hitherto unpublished.

The Erlwein process with lime, coke and nitrogen as raw materials and employing the reaction $CaO + 2C + 2N = CaCN^2 + CO$ was first cheaper than the Frank process, starting with carbide and nitrogen, as long as the carbide was high in price. The Erlwein process was carried out in electric fur-

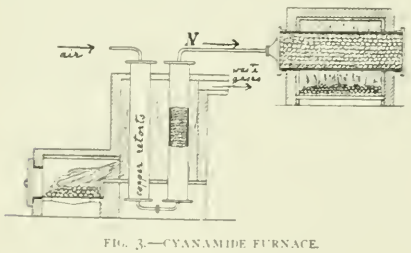


FIG. 3.—CYANAMIDE FURNACE.

naces of the form indicated in Fig. 2, similar to the Acheson type of furnace. They were 6 meters long, 3 meters wide and 3 meters high and had double walls so that the nitrogen could be introduced under pressure into the furnace. An exit was provided for the carbon monoxide gas.

Between the ends of the thick carbon electrodes a thin carbon rod was inserted. When the reaction started, this thin carbon rod first became incandescent and calcium cyanamide formed in concentric layers around it. After completion of the run the cyanamide could be removed in form of a porous cylinder.

When this process had been developed, the excessive calcium carbide boom in Europe had led to the inevitable crash and the price of carbide had fallen very essentially. Now it was found that the Frank process, starting with carbide, was the cheaper one and it was developed to a commercial success, as noted in our Vol. IV., p. 327. Its fundamental reaction is $CaC_2 + N_2 = CaCN_2 + C$.

The most important apparatus for the cyanamide process are those for making pure nitrogen from air and the cyanamide furnaces. To make pure nitrogen from air, either retorts containing copper (see the left half of Fig. 3) may be used, or the atmospheric air may first be liquified by the Linde process by means of strong pressure and cooling down to —194° C. and the liquid air then separated into nitrogen and oxygen by fractional distillation in apparatus of the kind used in alcohol stills.

The principle of the construction of the cyanamide furnaces is shown in the right half of Fig. 3. In the flame room of a coal-fired furnace* retorts are placed, closed air-tight and filled with powdered carbide to a certain height. They are heated to red or white heat and nitrogen gas is introduced into the furnace. Under these conditions the carbide eagerly absorbs the nitrogen; this is an exothermic process and the heat evolved accelerates the reaction. When the gasometer in the gas-supply pipe shows that the carbide does no longer absorb nitrogen, the incandescent cyanamide is removed from the retorts, cooled under absence of air, powdered and packed for shipping.

The cost of making calcium cyanamide depends on the cost of making pure nitrogen from air and on the price of calcium carbide, which is again determined by the price of the electric power. Carbide factories which pay $10 to $12.50 per hp.-year and pay otherwise "normal" prices for lime, coke and electrodes and "average wages," "may be sure to make a good profit by working their carbide into cyanamide, even if the price per kg. of nitrogen in the competing Chili saltpetre or ammonium sulphate (which is 37.5 and 32.5 cents, respectively, at present), drops considerably below the present market price. They are especially enabled to make profits if they have at the same time cheap power for operating a Linde plant, which, according to the size of the apparatus and according to the cost of power of 0.5 to 0.75 cents per kw.-hour, is able to produce pure nitrogen from air in continuous operation for 0.75 to 1.25 cents per cubic meter.

"Since modern and well-conducted carbide factories produce about 2 tons of carbide per kw.-year, and since 2 tons of carbide absorb about 500 kg. of nitrogen to form cyanamide, the fixation of 1 ton of nitrogen requires an expenditure of power of two kw.-years. This figure is interesting if compared with the energy required for binding 1 ton of nitrogen by processes using electric discharges through air for the purpose of making nitric acid, where even with the best efficiencies about 6.4 kw.-years are required."

The commercial calcium cyanamide (Kalk-Stickstoff) is a black powder, stable in air and consists of about 57 per cent of calcium cyanamide, 14 per cent of free carbon (which gives the black color), 21 per cent caustic lime, 2.5 per cent of silicic acid, 4 per cent of iron oxide and small quantities of sulphur, phosphorus and carbonic acid. The average content of nitrogen is 20 per cent.

When put into water, calcium cyanamide dissolves, but decomposes quickly (especially in hot water) yielding caustic lime, and, with polymerisation, a complicated compound called dicyanamide.

When treated with overheated steam, calcium cyanamide gives off its nitrogen quantitatively in form of ammonia.

Treated with acids in aqueous solution a number of highly interesting organic compounds are obtained under certain conditions. Among these products is urea.

When melted with sodium carbonate, sodium chloride, or other materials, the whole nitrogen in the cyanamide is

* Dr. Erlwein states that the process of changing the cyanamide into cyanide has been fully worked out, and will soon be the basis of a new cyanide undertaking, since the cyanide market is now in a much better condition.

* There is, therefore, nothing electrical whatever about this whole process, except the manufacture of the carbide.

changed into cyanide-nitrogen and the product when cooled consists of a mixture of calcium cyanide, sodium cyanide and the products of the decomposition of the added material.

Dr. Erlwein finally discusses briefly the practical applications of calcium cyanamide.

1. Cyanamide may be used directly as a fertilizer in agriculture. Those who are interested in the agricultural side of the problem will find interesting comparative pictures of the growth of plants under the fertilizing action of Chili saltpetre and calcium cyanamide, etc., in the original German paper.

2. Calcium cyanamide may be used for the production of ammonium sulphate, which is also consumed in large quantities for fertilizing purposes. The reaction yielding ammonia is $CaCN_2 + 3H_2O = CaCO_3 + 2NH_3$. The apparatus used for carrying out this reaction is shown in Fig. 4. It may be useful to provide such ammonium-sulphate factories as an addition to cyanamide factories in order to take care of the over-production.

3. Cyanamide may be used for the manufacture of dicyandiamide, a compound used in the manufacture of aniline colors and gun powder. By suitable leaching with water and crystallization, this compound is obtained in form of pretty white crystals. The chemical equation is

$$2CaCN_2 + 4H_2O = 2Ca(OH)_2 + (CNNH_2)_2.$$

4. Cyanamide may be used as starting material for the

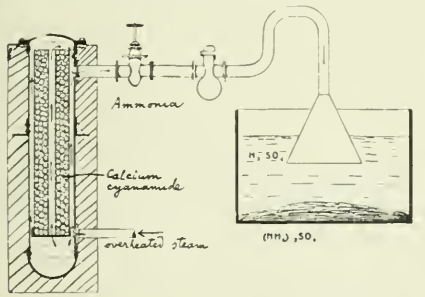


FIG. 4.—PRODUCTION OF AMMONIUM SULPHATE.

commercial manufacture of sodium cyanide or potassium cyanide. According to a process devised by Freudenberg, the calcium cyanamide is melted with sodium chloride in excess and is thereby transformed almost completely into sodium cyanide. The product obtained in this way, which contains about 22 to 23 per cent of sodium cyanide (corresponding to 30 per cent of potassium cyanide) is either sold directly in this form as so-called "sodium-cyanide substitute" (Cyannatrium-Surrogat) for use in gold metallurgy or is worked up into chemically pure sodium cyanide or potassium cyanide. Both brands will be made on a commercial scale as soon as a new factory is completed which is in course of erection near Berlin.

5. As a hardening material for iron and steel, calcium cyanamide has found a new sphere of application. This application is due to the ability of cyanamide to give off carbon to the iron which is thereby hardened. This ability is enhanced by the addition of other compounds to the cyanamide and this product is now sold under the trade name of "Ferrodur." Dr. Reininger, chief chemist of the well-known tool-steel and machine works of Ludwig Loewe, first recognized this property of cyanamide and called attention to the extremely uniform action of this new hardening material, which proves useful especially at such temperatures at which a uniform introduction of carbon into iron heretofore met with difficulties.

6. For the manufacture of urea a small plant is already in operation in which the calcium cyanamide is treated in a suitable way with acids and immediately changed into solutions of urea, which may be easily crystallized.

Metallurgical Calculations.

BY J. W. RICHARDS, PH. D.
Professor of Metallurgy in Lehigh University.

THERMAL EFFICIENCY OF OPEN-HEARTH FURNACES.

The ordinary open-hearth steel furnace receives cold pig iron, cold scrap, warm ferro-manganese, cold limestone and cold ore, it receives cold air and moderately warm producer gas, and it furnishes melted steel and slag at the tapping heat. The larger part of the usefully applied heat is that contained in the melted steel, for it must be melted in order to be cast, and when once taken away from the furnace the latter is done with it.

The total heat available for the purposes of the furnace and which should be charged against it consists of the following items:

(1) Heat in warm or hot charges.
(2) Heat in warm or hot gas as it reaches the furnace.
(3) Heat in warm or hot air as it reaches the furnace.
(4) Heat which could be generated by complete combustion of the gas.
(5) Heat of oxidation of those constituents of the charge which are oxidized in the furnace.
(6) Heat of formation of the slag.

The items of distribution of this total will be as follows:

(1) Heat in the melted steel at tapping.
(2) Heat absorbed in reducing iron from iron ore.
(3) Heat absorbed in decomposing limestone added for flux.
(4) Heat absorbed in evaporating any moisture in the charges.

These first four items constitute the usefully applied heat, and their sum measures the net thermal efficiency of the furnace.

(5) Heat absorbed in reducing ferric oxide to ferrous oxide
(6) Heat in the slag.
(7) Heat lost by imperfect combustion.
(8) Heat in the chimney gases as they leave the furnace.
(9) Heat absorbed by cooling water.
(10) Heat lost by conduction to the ground.
(11) Heat lost by conduction to the air.
(12) Heat lost by radiation.

(1) HEAT IN WARM CHARGES.

If the pig iron is charged melted instead of cold an immense amount of thermal work is spared the furnace, and it should be charged with all the heat (reckoning from 0° C. as a base line) which is in the melted pig iron as it runs into the furnace. This will average 275 Calories per unit of pig iron, but should be actually determined calorimetrically in each specific instance wherever possible. The net thermal efficiency of the furnace will figure out higher with cold charges than with melted pig iron, because, with a possible flame temperature of 1,900° C. in the furnace, heat is absorbed much more rapidly by cold charges than by hot ones, and a larger percentage of the available heat will be thus usefully applied.

Scrap is almost always charged cold, but if any of it is hot its weight and temperature should be known and the amount of heat thus brought in charged against the furnace. Or a small piece may be dropped into a calorimeter and its heat content per unit of weight measured directly, and thus the heat in all the hot scrap used may be estimated.

Ferro-manganese is often added cold, but usually is preheated to cherry redness (about 900°) in another small furnace, in order that it may dissolve more quickly in the bath. Knowing its weight, temperature and specific heat, the heat which it brings into the furnace can be calculated; a better plan is to drop a piece into a calorimeter and measure the actual heat in a sample of it.

Limestone and ore are almost invariably put into the furnace cold. It is how the heat in them can be determined in the manner described.

(2) Heat in the Gas Used.

By this is meant not the heat in the gas after it is heated in the regenerators, but its sensible heat as it reaches the furnace. This applies only to furnaces where the producers or gas supply are independent of the furnace. Where the producers are an integral part of the furnace it is impracticable to consider them separately from the furnace, and the efficiency of the whole plant, including the producers, must be considered together. But where the gas supply from whatever source comes to the furnace from outside, and reaches the furnace warm, its sensible heat is to be charged against the furnace as part of the heat which the furnace must account for. If the gas comes from producers its amount is satisfactorily found from the known weight of carbon gasified per hour, or per furnace charge, and the weight of carbon contained in unit volume of gas, as calculated from its analysis. If gas comes from a common main which supplies several furnaces, or is simply natural gas, its amount can only be roughly estimated by measuring the area of the gas supply pipe or flue and measuring the velocity of flow by a pressure gauge or Pitot tube or anemometer. None of these methods just mentioned are satisfactorily accurate, and there is great need of simple methods for determining accurately the flow of gases in flues or pipes. If the velocity of warm gas is determined suitable correction for its temperature must be made to reduce it to volume at standard conditions.

(3) Heat in the Air Used.

If the air coming to the furnace is warm its sensible heat must be charged against the furnace. If the air is warmed, however, before it goes into the regenerators by waste heat from the furnace itself, then its sensible heat should *not* be charged against the furnace, because that would amount to charging the furnace twice with this quantity of heat. Such preheating is in reality only a part of the regenerative principle, even though it may not be done in regenerators, but, for instance, by circulating air around a slag-pot or through the hollow walls of the furnace. If the air used is moist its moisture should not be omitted in the calculation.

The amount of air used is best determined by a comparison of the analyses of gas and chimney products, and a calculation based on the carbon contents of each and the known volume of gas used.

(4) Heat of Combustion.

Under this head comes the principal item of heat available for the furnace. In reckoning it we should calculate the total heat which could be generated by the perfect combustion of the gas used, to CO^2, N^2 and H^2O vapor. If there is in reality imperfect combustion, as is shown by analysis of the chimney gases, that is a defect of operation of the furnace which should be written down against it. Problem 68 showed an actual case in which there was very incomplete combustion in the body of the furnace, but where combustion was afterwards completed in the regenerators. In such a case the same principle applies; the furnace must be charged with the total calorific power of the fuel used, and incomplete combustion can be charged against the furnace as a whole only on the basis of unconsumed ingredients in the chimney gases—the products finally rejected by the furnace. If there is poor combustion in the body of the furnace and combustion is only completed in the regenerators, the furnace will not give as high net thermal efficiency as if combustion were complete above the hearth.

(5) Oxidation of the Bath.

The oxidation of carbon, iron, silicon, manganese and sometimes phosphorus and sulphur, add a not inconsiderable amount to the heat resources of the furnace. Carbon should be burnt to CO^2, iron is usually oxidized to FeO, manganese to MnO, silicon to SiO^2, phosphorus to P^2O^5, and sulphur to SO^2. All of these oxidations generate heat, and, moreover, heat which should be very efficiently utilized, being produced in direct contact with the metallic bath; it should all be charged against the furnace as part of its available heat.

(6) Formation of Slag.

The metallic oxides produced unite with each other, and with the lime and silica of ore used and lining of the hearth to produce the slag, the heat of formation of which can be calculated and counted in as available heat.

(1) Heat in Melted Steel.

This is a large item in the work done by the furnace; in fact, usually the largest single item. It should be determined calorimetrically when possible; if this is not done its temperature should be known and its composition, in order to compare it with the calorimetric experiments of others, and thus derive a probable value for its heat contents. Not many experimental values in this line have so far been published, and a very much needed investigation is one upon the total heat in melted steels of different compositions at different temperatures. Values from 275 to 350 Calories per kilogram have been observed.

(2) Heat of Reduction of Iron from Ore.

This is an item which appears whenever ore is used to facilitate oxidation of the bath. The weight and composition of the charges and the products will easily show how much iron has been reduced. The ore used is almost always hematite, less frequently magnetite; hydrated iron oxides are not used for obvious reasons. The heat absorbed is 1,746 Calories per kilogram of iron reduced from Fe^2O^3 and 1,612 Calories per kilogram from Fe^3O^4.

(3) Decomposition of Limestone Flux.

If limestone is charged raw, as is usually done in order to avoid the dusting caused by using burnt lime, then the furnace is called upon to burn this limestone in place of the lime kiln. The heat absorbed may be taken as either

451 Calories per kilogram of $CaCO^3$ decomposed.
1,026 Calories per kilogram of CO^2 driven off.
806 Calories per kilogram of CaO produced.

(4) Evaporation of Moisture in the Charges.

If the ore, flux, scrap or ore are put into the furnace wet their moisture must be evaporated. The correct figure for this evaporation is the latent heat at ordinary temperatures, viz.: 606.5 Calories per kilogram. This allows for the heat required to convert into cold vapor of water, and puts the H^2O thereafter upon the same basis as all the other gas going out of the furnace. The chimney gases carry out sensible heat, and the H^2O in them can be calculated as carrying out a certain amount of heat as gas, reckoning from zero, and thus the correct chimney loss obtained. It is incorrect either to charge the latent heat of vaporization as chimney loss or to charge the sensible heat of the water vapor in the chimney gases to heat absorbed in evaporating water in the furnace. It is also incorrect to do as is frequently done, viz.: to calculate the heat required to evaporate the moisture to water vapor at 100°—637 Calories—and say that this is the heat to evaporate the moisture. With almost no moisture in the gases, the moisture of the charges would commence to evaporate at once, while they were yet cold, and the moisture is no more evaporated at 100° or to vapor at 100° than it is to 200° or 500°. The only safe course is to confine the evaporation heat to that necessary to convert the moisture into cold vapor, and let its sensible heat as it escapes as vapor at any other temperature be reckoned in with the sensible heat of the chimney gases.

(5) Reduction of Ore Into the Slag.

While considerable of the iron in the ore used is reduced to the metallic state, yet often the larger part is reduced merely

to the state of FeO, and as such goes into the slag. The amount so reduced can be determined by subtracting the iron reduced from ore from the total iron in the ore used; the difference gives the iron from the ore going into the slag as FeO. The weight of FeO corresponding is then easily calculated. The heat absorbed in this partial reduction is:

446 Calories per kilogram of FeO reduced from Fe^2O^3.
341 Calories per kilogram of FeO reduced from Fe^3O^4.

(6). Heat in Slag.

This is usually a small item in open-hearth practice, but may amount to a very considerable one in the method of running with large ore charges, as in the Monell process. The variations of composition of the slag, and especially in the temperature at which it is run off, are so large that the heat in the slag should always be determined calorimetrically for each specific case. If assumptions have to be made, 450 to 550 Calories per kilogram of slag would be assumed. The weight of slag is seldom taken, although it could in most cases be done if desired. If the weight is not known it may be calculated from the known weight of either iron, manganese or phosphorus going into it, as seen from the balance sheet, and the percentages of these elements in the slag as shown by analysis.

(7) Loss by Imperfect Combustion.

This is based upon the unconsumed ingredients of the chimney gases, as shown in an analysis. From this the calorific power of the unburnt gases in 1 cubic meter can be calculated. If then we know the volume of chimney gases per unit of charge, we get the heat loss by imperfect combustion per unit of charge. The volume of chimney gas is found by means of the carbon in it, which must all come from the carbon in the gas used, plus the carbon oxidized out of the charges, plus the carbon of CO^2, driven off raw limestone used as flux. Or, putting it in another way, the total carbon going into the furnace in any form, less the carbon in finished steel, must give the carbon in the chimney gases. This divided by the weight of carbon in unit volume of chimney gas gives the volume of the latter, per whatever unit of charge is used as the basis of calculations. This volume times the calorific power of unit volume of chimney gas, gives the total heat lost by imperfect combustion.

(8) Sensible Heat of Chimney Gases.

The temperature of these gases should be taken as they enter the chimney flue. Their amount is determined as explained under the previous heading. The water vapor contained should not be overlooked, being reckoned simply as vapor or gas in exactly the same category as the other gases. The analysis of the chimney gases being usually given on dried gas, a separate determination of the moisture carried per unit volume of such dried gas is necessary. If this is not done an approximation can be made by considering all the hydrogen in the gas burned to form water vapor, and add in the moisture of the air used and the moisture in the charges.

(9) Heat Lost in Cooling Water.

This is a very variable amount, and must be determined for each furnace by measuring the amount of water used per unit of time and its temperature before reaching and after leaving the furnace. Doors are frequently water-cooled, also ports, where the heat is fiercest, and sometimes a ring around the hearth at the slag line.

(10) Loss by Conduction to the Ground.

This is a quantity extremely difficult to measure or to estimate. If a closed vessel filled with water were put into the foundations the rate at which its temperature rose might give some idea of the rate at which heat passed in that direction per unit of surface contact. At present, lacking all reliable data, we must put this item in the "by difference" class.

(11) Loss by Conduction to the Air.

This is an amount which can be observed and calculated with some approach to satisfaction. The *sine qua non* for this purpose is a Fery radiation pyrometer, by which the temperature of the outside of the furnace at different parts can be accurately determined. Then the velocity of the air blowing against the furnace, if it is in a current of air, is observed with a wind gauge, and its temperature before reaching the furnace. With these data and by the methods of calculation before explained in these calculations (March, 1906) the heat lost to the air may be calculated.

(12) Radiation Loss.

Having determined the temperature of the outer surface of the furnace and measured its extent, as above explained, the radiation loss can also be calculated, knowing the mean temperature of the surroundings, by the principles of radiation, having due regard to the nature of the radiating surface. Tables of specific radiation capacity of different substances (fire-brick, stone, iron) will be found at the reference just given above.

Problem 69.

Jüptner and Toldt (Generatoren und Martinöfen, p. 73) observed the following data with regard to an open-hearth steel furnace charge:

Weight of cold charges, at 26° C.		3,745 kg.
Weight of hot charges, at 700° C.		1,700 "
Total weight of charge		5445 "
Average composition of charge	C =	1.07 per cent
	Si =	0.50 "
	Mn =	1.33 "
Coal gasified in producers		1,980 kg.
Carbon gasified from coal		47.13 per cent
Average composition of dried gas used	CO^2	3.81 "
	O^2	0.98 "
	CO	23.82 "
	CH^4	0.42 "
	H^2	8.75 "
	N^2	62.22 "
Moisture accompanying each m^3 of gas	=	82 grams
Temperature of gas reaching furnace		165° C.
Temperature of air used		26° C.
Moisture accompanying each m^3 of air		12 grams
Barometer		717 m. m.
Steel produced		5,191 kg.
Composition of Steel	C =	0.12 per cent
	Si =	0.04 "
	Mn =	0.19 "
Temperature of steel when tapped		1410° C.
Heat in 1 kg. steel, by calorimeter (to 0° C.)		277 Cal.
Composition of slag	SiO^2	45.65 per cent
	FeO	33.60 "
	MnO	18.21 "
	CaO	2.54 "
Weight of slag		425 kg.
Temperature of slag when issuing		1410° C.
Heat in 1 kg. slag, by calorimeter (to 0°)		560 Cal.
Composition of the stack gases (dry)	CO^2	11.12 per cent
	O^2	6.78 "
	N^2	82.10 "
Temperature of the gases in chimney flue		500° C

Requirements:

(1) A balance sheet of materials entering and leaving the furnace

(2) A balance sheet of the heat available and its distribution.

(3) What excess of air above what is necessary for complete combustion is used, and what per cent of all the available heat of the furnace is thereby lost?

(4) What is the thermal efficiency of the furnace?

Solution (1)

Balance Sheet of Materials.

Charges.		*Steel.*	*Slag*	*Gases.*
Metal,	5,445 kg.			
C,	58 "	6	...	52
Si,	27 "	2	25	....
Mn,	72 "	10	62	....
Fe	5,288 "	5,173	115	....
Limestone,	20 "			
CaO,	11 "	....	11	....
C,	2.5 "	....	....	2.5
O,	6.5 "	....	....	6.5
Hearth,				
SiO^2	132 "	....	132	....
Gas,	7,884 "			
C,	933 "	..	.. .	933
O,	2,003 "	..	....	2,003
H,	118 "	..	..	118
N,	4,830 "	..	.. .	4,830
Air,	16,026 "			
O,	3,812 "	.	80	3,732
N,	12,195 "	.	...	12,195
H,	19 "	.	.	17
Totals,	29,507 "	5,191	425	23,891

Notes on the Balance Sheet.

The distribution of carbon, silicon, manganese and iron is governed by the known amounts of these elements present in the steel, the rest of the carbon going into the gases (as CO^2), and the manganese, silicon and iron passing into the slag (as MnO, SiO^2 and FeO, respectively).

The amount of limestone used was not stated, but was deduced from the fact that the slag was said to weigh 425 kilos. and to contain 2.54 per cent of CaO, which makes the CaO 11 kilos., and assuming pure limestone, this would bring in 9 kilos. of CO^2, which appears on the balance sheet as 2.5 kilos. of carbon and 6.5 kilos. of oxygen, contributed to the gases.

The weight of silica contributed by the hearth is deduced from the fact that the slag must contain the silicon, manganese and iron oxidized from the charge, as SiO^2, MnO and FeO, the CaO of the flux and the SiO^2 contributed by the hearth, and its total weight is 425 kilos. The ingredients of the slag must, therefore, be

		Kg.
SiO^2	$25 \times 60/28 =$	53.5
MnO	$62 \times 71/55 =$	80.0
FeO	$115 \times 72/56 =$	147.9
CaO	$=$	11.0
	Sum	293
From hearth (difference)		132
Total slag		425

The gas used we find by starting with the fact that 1,980 kilos of coal is used, from which 47.13 per cent of carbon enters the gases. This makes carbon in the gases 933 kilos. Each cubic meter of dry gas, as analyzed, contains 0.2805 cubic meter of CO^2, CO and CH^4 added together, and, therefore, $0.2805 \times 0.54 = 0.1515$ kilos of carbon. The volume of dry producer gas used is therefore, at standard conditions, $933 \div 0.1515 = 6,160$ cubic meters, containing by its analysis:

CO^2	$6,160 \times 0.0381 =$	235 m^3 =	465 kg.	
O^2	" $\times 0.0098 =$	60 m^3 =	86	"
CO	" $\times 0.2382 =$	1,467 m^3 =	1,840	"
CH^4	" $\times 0.0042 =$	26 m^3 =	19	"
H^2	" $\times 0.0875 =$	539 m^3 =	49	"
N^2	" $\times 0.6222$	3,833 m^3 =	4,830	"
		6,160 m^3 =	7,297	"

The moisture is 82 grams per each cubic meter of gas, measured at 26° and 717 m.m. pressure; but the 6,160 cubic meters of gas at standard conditions would be 7,175 cubic meters at those conditions of temperature and pressure, and therefore be accompanied by

$$7,175 \times 82 = 588,350 \text{ grams}$$
$$= 588 \text{ kg. of } H^2O \text{ vapor.}$$

We can now enter the gas on the balance sheet either as so much CO^2, CO, H^2O, etc., or else resolve it into its essential constituents C, H, O and N, which course we have followed on the balance sheet. The carbon in the gas is 933 kg. by assumption; the oxygen is 8/11 the CO^2, all the O^2, 4/7 the CO and 8/9 the H^2O, a total amounting to 2,003 kilos; the hydrogen is 4/16 the CH^4, all the H^2 and 1/9 the H^2O, a total of 118 kilos.

The air supplied is best found from the volume of the chimney gases. The total carbon entering these is 52 + 2.5 + 933 = 987.5 kilos., as seen from the balance sheet. Each cubic meter of dry chimney gas contains 0.1112 m^3 of CO^2, carrying $0.1112 \times 0.54 = 0.0600$ kilos. of carbon. The volume of dry chimney gas at standard conditions is therefore $987.5 \div 0.0600 = 16,458$ m^3. This contains $16,458 \times 0.8210 = 13,512$ m^3 of N^2, and since 3,833 cubic meters came in with the gas 9,679 m^3 must have come in with the air, corresponding to 12,220 m^3 of dry air at standard conditions. This would consist of 12,195 kilos. of N^2 and 3,660 kilos. of O^2. To find the moisture present the volume of this air at 26° and 717 m.m. pressure would be 14,230 m^3, and would be therefore accompanied by

$$14,230 \times 12 = 170,760 \text{ grams}$$
$$= 171 \text{ kg. of } H^2O.$$

This consists of 19 kilos. of hydrogen and 152 kilos. of oxygen, the latter increasing the total oxygen in the air used to 3,660 + 152 = 3,812 kilos.

(2) Heat Balance Sheet.

Heat Available.	*Cal.*	*Per-centages.*
Heat in the warm charges	189,210 =	2.45
Sensible heat of air used	90,480 =	1.29
Sensible heat of gas used	360,550 =	4.68
Heat of combustion of gas	6,202,300 =	80.44
Heat of oxidation of the bath	833,600 =	10.81
Heat of formation of slag	24,200 =	0.31
Total	7,709,340 =	100.00
Heat Distribution.		
In melted steel at tapping	1,437,900 =	18.65
Decomposition of limestone	9,200 =	0.12
Sensible heat of slag	238,000 =	3.09
Sensible heat of chimney gases	3,118,450 =	40.45
All other losses, not classified	2,905,790 =	37.69
Total	7,709,340 =	100.00

Notes on the Heat Balance Sheet.

The warmed charges weighed 1,700 kilos at 700°, and the cold charges 3,745 kilos. at 26°. Taking 0° C. as the base line the sensible heat in these is

	Cal.
$1,700 \times 0.15 \times 700 =$	178,500
$3,745 \times 0.11 \times 26 =$	10,710
Sum =	189,210

The air used contains, at standard conditions, 12,220 m^3 of air and $171 \div 0.81 = 211$ m^3 of water vapor. These carry, at 26°, heat as follows:

	Cal.
$12,220 \times 0.3037 \times 26 =$	98,490
$211 \times 0.3439 \times 26 =$	990
Sum =	99,480

The gas used, coming in at 165° C., carries in heat as follows:

		Cal.
O^2, CO, H^2, N^2	5,899 m³ × 0.3075 =	1,814
CO^2	235 m³ × 0.4003 =	95
CH^4	26 m³ × 0.4163 =	11
H^2O	720 m³ × 0.3648 =	265
Average calorific capacity per 1	=	2,185
Heat content 2,185 × 165	=	360,525

The heat of combustion is that of the combustible ingredients of the gas used to CO^2 and H^2O vapor:

		Cal.
CO	1,467 m³ × 3,002 =	4,492,000
CH^4	26 m³ × 8,598 =	223,500
H^2	539 m³ × 2,613 =	1,480,800
Sum =		6,202,300

The heat of oxidation of the bath is from the various substances oxidized:

	Cal.
C to CO^2	52 × 8,100 = 421,200
Si to SiO^2	25 × 7,000 = 175,000
Mn to MnO	62 × 1,653 = 102,500
Fe to FeO	115 × 1,173 = 134,900
Sum =	833,600

The heat of formation of the slag is the heat of combination of 80 kilos. of MnO, 148 kilos of FeO and 11 kilos. of CaO, with 186 kilos of SiO^2. This will be, since the bases are largely in excess of the silica:

$$186 \times 130 = 24,200 \text{ Cal.}$$

The figure 130 is an average for the heat of combination of 1 kilo. of SiO^2 with about 2 parts of FeO to 1 part MnO.

The heat in the steel at tapping is simply its weight multiplied by its heat contents per kilo. (5,191 × 277).

The heat in the slag is similarly obtained (425 × 560).

The decomposition of limestone represents 9 kilos. of CO^2 liberated, and the heat absorbed is 9 × 1,026.

The sensible heat in the chimney gases is obtained by first noting that their volume (measured dry), as already obtained, is 16,458 cubic meters. The CO^2, 11.12 per cent, becomes, therefore, 1,843 m³; the O^2, 1,116 m³; N^2, 13,512 m³, while the H^2O accompanying this will be 9 times the weight of hydrogen passing into the gases, which is 9 × (118 + 17) = 1,215 kilos. = 1,500 m³. A simpler way to get the volume of the water vapor is to observe that it is always equal to the volume of hydrogen going into it, and, therefore, in this case would be (118 + 17) ÷ 0.09 = 1,500 m³. The heat carried out by these gases would therefore be:

N^2 + O^2 =	14,628 m³ × 0.3165 =	4629.8 Cal. per 1°	
CO^2 =	1,843 m³ × 0.4800 =	984.4 "	"
H^2O =	1,500 m³ × 0.4150 =	622.5 "	"
Calorific capacity	=	6236.9 "	"
Total capacity	=	3,118,450 "	" 500

The heat balance sheet as a whole discloses the fact that in this furnace the fuel only supplies some 80.5 per cent of the total heat available, and that about 10.8 per cent is furnished by the oxidation of the bath itself. On the other hand, the melted steel accounts for 18.6 per cent, while chemical reactions absorb almost none, giving a net thermal efficiency of slightly under 19 per cent. The other important items are 40.5 per cent of the total heat lost up the chimney, and 38 per cent lost by radiation and conduction. Such data as these point the way to avenues of possible saving or avoidance of waste of heat.

(3) The excess of air is obtained directly from the chimney gases. The 1,116 m³ of oxygen, unused, represents 1,116 ÷ 20.8 = 5,365 m³ of air in excess, which leaves 16,458 − 5,365 = 11,093 m³ of air which came in and was used. The percentage of air used in excess of that which was necessary was:

$$5,365 \div 11,093 = 0.4845 = \mathbf{48.5} \text{ per cent.} \qquad (3)$$

No properly run open-hearth regenerative gas furnace should ever have such a large excess of air, for it cuts down the temperature of the flame and leads to high chimney losses.

The air used brought in 171 kilos of water vapor, and therefore the excess air brought in

$$171 \times \frac{48.5}{148.5} = 56 \text{ kilos. of water,}$$

the volume of which, at standard conditions, would be

$$56 \div 0.81 = 61 \text{ cubic meters.}$$

The excess air, with its accompanying water, going into the chimney at 500°, carried out heat as follows:

	Cal.
5,365 × 0.3165 × 500 =	849,000
61 × 0.4150 × 500 =	12,650
	861,650

Representing 861,650 ÷ 7,709,340 = 0.112 = **11.2** per cent. (3)

(4) The thermal efficiency has been already added up as

$$18.65 + 0.12 = \mathbf{18.77} \text{ per cent.} \qquad (4)$$

Electrometallurgy of Zinc.

At a meeting of the New York section of the American Electrochemical Society, held on Jan. 30 at the Chemists' Club (Prof. Sam. A. Tucker in the chair), Mr. Woolsey McAlpine Johnson, metallurgist of the Tri-Bullion Smelting & Development Co., presented a very interesting paper on the electrometallurgy of zinc, reviewing the attempts made in recent years to treat zinc ores by electrometallurgical means, both in ore-dressing, by electrolytic processes and by the electric furnace.

This development has had the great effect of stimulating new work in the metallurgy of complex sulphide ores of lead, copper, zinc, and by advance in the methods of concentrating zinc ores it has opened up mines, once valueless, into producers and profit-makers.

Electrostatic and Electromagnetic Separators.—Of the three electrostatic separators which have been fairly successful in experimental work—the Huff-Dolbear, the Sutton-Steele and the Blake-Morscher—one, the Blake-Morscher has become a commercial machine (see our Vol. III., p. 181). Sulphides with a metallic lustre are, in general, conductors of electricity. The only mineral sulphide of any importance which is not a conductor is "resin jack," the sulphide of zinc. For this reason electrostatic separation is possible of resin jack from iron pyrites. Separation by water concentration would not be possible on account of the specific gravities being close together.

Among industrial electromagnetic separators the Wetherill, the Ding, the Cleveland-Knowles and the "International" are best known.

The Wetherill separator was developed at the Franklin Furnace mines of the New Jersey Zinc Co., where, after a preliminary water concentration the ore is dried and the magnetic franklinite (a compound of zinc oxide, iron oxide, and manganese oxide) is separated by Wetherill machines from the willemite, the anhydrous silicate of zinc. (Concerning the further treatment of these products, see our Vol IV., p. 89).

In the West the electromagnetic separator is used in two ways: First, to separate the magnetic oxy-sulphide of iron made by roasting the ore at a low temperature; second, to treat the ore directly for the elimination of the magnetic sul-

phide of zinc and iron, called marmatite. The product which contains 38 to 44 per cent of zinc is well suitable for the spelter furnace. This method is carried out at the Empire Zinc Works, at Canon City, Col., and also at the Rowe Mill of the American Zinc Extraction Co., of Leadville.

A rather complex treatment of Leadville ore is used by the Colorado Zinc Co., at Denver. The ore is crushed and sized on "King" screens. It is then passed over Wilfley tables yielding (a) siliceous tailings, (b) zinc-iron middlings, and (c) lead concentrates. The siliceous tailings are rejected, while the lead concentrates go to a lead plant. The zinc-iron middlings are dried and passed over a Wetherill electromagnetic machine where the magnetic black-jack is eliminated and sold to a spelter plant as a zinc ore. The non-magnetic product is treated by Blake-Morscher electrostatic separators, producing an iron product low in zinc, and a zinc product suitable for the spelter plant. If the previous magnetic treatment were not inserted, the iron product from the Blake separators would be high in zinc and thus unsuitable for a flux for the lead smelter, and, besides, loss in zinc would be heavy.

The other electromagnetic concentration process is used most largely in the Wisconsin zinc field, which, just on this account, has developed so rapidly as a zinc producer. The concentrates produced here often contain more than 50 per cent zinc. This method will undoubtedly be used in the Rocky Mountain States for the treatment of complex sulphides.

Electrolytic Processes.—In passing over to a review of electrolytic processes of zinc production, Mr. Johnson first dealt with processes designed for the decomposition of the chlorides of lead and zinc in fused condition. He sketched the Swinburne-Ashcroft process (see our Vol. I., p. 413, II., p. 404, and III., p. 63, as well as the series of articles by Mr. Ashcroft in our Vol. IV.), but he thinks that the process has to meet considerable difficulties, mostly due to its complicated nature. Especially the separation of copper, iron and manganese in the wet way might be troublesome. Mr. Johnson believes that the process "will not produce a metallurgical revolution, though it may find a niche in the art of zinc smelting."

Mr. Johnson then mentioned briefly the very similar work done by Messrs. Baker and Burwell, in Cleveland, Ohio, and in Montana (our vol. III., p. 154, Vol. IV., p. 193, Vol. V., p. 50), but thinks it unlikely that this process will ever reach a practical basis. Besides, it has small novelty, being subsequent to the Swinburne-Ashcroft work.

Of wet electrolytic processes Mr. Johnson mentioned that of the late Dr. Hoepfner (see, for instance, our Vol. I., pp. 540 and 568), using hydrochloric acid as solvent. But the leaching of the zinc is imperfect. Gelatinous silica is formed, which is most troublesome to filter press. Much iron is dissolved, which adds to the expense of the plant and cost of treatment.

Nevertheless the Hoepfner process is commercially used by the Brunner-Mond Co. to a small extent, because it enables them to use a by-product and to produce a much higher grade of zinc, which sells in a limited way at a price much above the market price of the average grade of spelter.

Leaching of the roasted ore with alkaline solvents, on the other hand, with the production of alkaline plumbate and zincates is considered by Mr. Johnson to be more promising. The iron oxide is, of course, not dissolved and the silica problem is of a less troublesome nature. The "differential electrolysis," by which lead is deposited at a low potential and zinc at a higher potential, presents difficulties, as does the chemical engineering of this problem. But compared with the Hoepfner process and the Swinburne-Aschroft proposition, Mr. Johnson thinks this method is distinctly promising.

Electric Furnace Developments.—In passing over to this subject, Mr. Johnson came out with the flat-foot statement that the use of the electric furnace in zinc metallurgy is apparently extremely attractive. Granted electric power from a water-power station at $12 to $20 per hp.-year, capital invested per ton of spelter produced per year would be small. An electric resistance furnace treating zinc ore will put through an enormous tonnage per cubic foot of active space.

The labor charge, high in the present spelter plant, will be low in a continuous electric zinc furnace. As the heats in a good electric zinc furnace are under good control, the recovery of metal will be high. The corrosive nature of certain zinc ores will not be a disturbing factor, for the furnace may be lined with suitable refractory material so that certain ores which are not now available may be used.

The spelter made will be pure, and as it is made in large amounts it will be of uniform purity—quite the reverse of spelter made in the present small retorts. The thermal efficiency of the furnace is high. Eighty-five per cent can be safely counted on in a 500-kw. furnace. Finally there will be a better recovery of lead, silver, copper and gold values.

If, instead of an hydro-electric plant, gas engines should be used, driving electric generators, with a combined efficiency of 23 per cent, the total thermal efficiency of such a zinc works may be assumed to be .85 by 23 per cent. or about 19.5 per cent, which is much more than the present thermal efficiency of 4 to 6 per cent in American practice, and 8 to 10 per cent in good Belgian and German practice (although it may be hoped that in American practice the European figures will soon be reached).

Mr. Johnson then pointed out that in the old retort furnace as used at present, the thermal efficiency is fairly high at the start of the operation, and low at the end. As a rough figure in the Kansas natural gas plants, two-thirds of the spelter is made with one-third of the fuel. This suggested to Mr. Johnson a combination process in which a "preheater" was to perform the first and easy part of the work in form of a regenerative gas furnace with retorts, which would then discharge its partially reduced charge into an electric furnace where the finishing reduction was performed by the more effective but the more expensive heat of the electric current. While Mr. Johnson agreed that this method involved great mechanical and metallurgical difficulties, he stated that he had solved them absolutely on a small scale.

Mr. Johnson has, however, given up this line of work for the present, since the ores of the Kelley mine, owned by the Tri-Bullion Smelting & Development Co. (with which he is now connected), are high in zinc, and are susceptible to treatment by the old process at a large profit compared with the treatment of the ores of competing mines. For these reasons the Traylor Engineering Co., which is erecting the zinc plant for the Kelley mine, considered it much better business not to attempt at once any radically new departure, but to stick to old, tried methods of concentration and reduction with most up-to-date modern apparatus.

The chief trouble from a metallurgical standpoint with the electric zinc furnace is to condense the zinc vapor on a large scale to metallic zinc and not to zinc dust or blue powder. This trouble is directly due to the difficulty of maintaining the proper uniform temperature relations during condensing on a large scale. But these difficulties are certainly not insurmountable. Mr. Johnson also called attention to the great danger to attendants, due to the fact that zinc and carbon oxide at 800° C. are extremely explosive.

Mr. Johnson then referred to the work of Brown and Oesterle, who experimented with a resistance furnace, endeavoring to produce zinc from unroasted ore and to produce at the same time calcium carbide (see our Vol. III., p. 378).

Mr. F. T. Snyder (see also our Vol. IV., pp. 152 and 503), has attempted to reduce in the Siemens electric furnace zinc-lead ores, producing a slag carrying the earthy impurities, metallic lead collecting the gold and silver, and metallic zinc in the condenser of his furnace. Even if there are difficulties in condensing, Snyder may condense his zinc vapor, not to spelter directly, but to blue powder, which may then be treated in the old-fashioned retort like a high-grade zinc ore. Mr. Johnson thinks very well of the process.

Mr. Gustav De Laval (see also our Vol. I., p. 425, and Vol. II., p. 423), has worked his electric furnace on zinc skimmings from the galvanizer or on low-grade "leady" spelter (94 per cent zinc). He produces a high-grade spelter (analyses of which were given on page 54 of our Vol. III). He has now modified his ore process and uses a reaction something similar to the reaction used on the Wetherill grate of the New Jersey Zinc Co. The roasted ore and coal are blown into the furnace in a whirl and the lighter products are drawn off from the sides, while the heavier are drawn off in the center. Thus, De Laval uses centrifugal force (so characteristic of his other engineering work) in this furnace. De Laval uses this high-grade zinc oxide (70 to 80 per cent zinc) in his electric furnace for the production of spelter.

In this connection, Mr. Johnson remarked that the Wetherill process could be used, if modified rightly, for the same purpose. The New Jersey Zinc Company in fact, does this to some extent. The zinc oxide formed mixed with coal may be reduced to metallic zinc in the old-fashioned retort.

Possibilities of the Old Zinc Retort.—At the conclusion of his paper Mr. Johnson remarked that the old retort has certain definite limitations prescribed by the nature of fire clay; on the other hand, it has certain lines of possible development. Mr. Johnson expressed himself greatly in favor of larger retorts. He also favors mechanical charging. Finally he expressed his conviction that electrical methods will be used largely in the future in the concentration of complex sulphides and in the reduction of the resulting zinc concentrates to spelter—which is one of the widest and most fascinating fields in the domain of metallurgy.

Iron and Steel from Black Sands.

The United States Geological Survey has just issued a report of 84 pages, by Dr. DAVID T. DAY, chief of Division of Mining and Mineral Resources of the Geological Survey, and Prof. R. H. RICHARDS, of the Massachusetts Institute of Technology, on Black Sands of the Pacific Slope in 1905.

In this report the expression "black sands" is used to embrace the residual sands left in concentrating placer gravels. Usually they denote the heavy materials left in the sluice boxes in placer mining, but they include also both the black sands left by the concentrating action of waves and the natural concentration products of stream action. They consist principally of minerals with a specific gravity above 3; and, although the expression "heavy sands" would be more appropriate, they are, as a rule, darker in color than the gravel from which they are obtained, and the expression "black sands" has become general.

The United States Geological Survey was authorized by Congress in 1905, to investigate the useful minerals which are contained in, and could be won from the blacks sands

In the beginning of the investigation a circular letter was sent to all the placer miners of the United States whose addresses were known, some 8,000 in all, authorizing them to send in samples of the black sands obtained by them, up to 4 pounds for each sample. The examination of these samples, partly in Boston, Mass., and partly in Portland, Ore., showed that the following minerals, in the order named, are most commonly found in these sands: Magnetite, gold, ilmenite, garnet, zircon, hematite, chromite, platinum, iridosmium, mercury, amalgam, olivine, and iron silicates, pyrite, monazite, copper, cinnabar, cassiterite, and corundum. Other heavy minerals are only exceptionally found. The largest field of platinum, and the most profitable field for commercial exploitation, is comprised in Coos, Jackson, Curry and Josephine Counties, Ore., and in Del Norte, Siskiyou, Humboldt and Trinity Counties, Cal.

In an extended study of concentration methods it was found that with careful sizing it is possible to separate gold and platinum from these sands with comparative ease and with small expense by use of concentrating machines of the shaking-table class, and partial separation of various other minerals can be made at the same time, so as to render available for the market at a low cost monazite, zircon, ilmenite, chromite, garnet and cassiterite. It was also found that the magnetite contained in the black sands of the Pacific slope constitutes a greater supply of useful iron ore than any other available source known on the Pacific slope. This magnetite usually contains from 5 to 10 per cent of titanium. "It was found that this titanium offered no obstacle to the production of high-grade cast iron in the electric furnace, and that in a modification of this electric furnace this cast iron could even be decarburized to a very soft iron of high quality. Facilities were not at hand for smelting this iron in an ordinary blast furnace."

The report gives in great detail the preliminary work of the present investigation, including field examinations. Extensive tables are then given of analyses of more than 800 samples of black sand received from various districts in America. Then follow analyses of about eighty samples of concentrates from various localities in which only the gold and the platinum were determined and finally about seventy analyses are given, made by Messrs. Baker & Co., of Newark, N. J., of the percentage of platinum and iridosmium in assay buttons, since later investigations at Portland had developed many assays for gold where platinum was suspected.,

Then follows the report by Prof. R. H. Richards on the methods of concentration. The following machines were used: screens, hydraulic classifier, hand jig, Wilfley table, Pinder table, Woodbury table, Christonsen table, Wetherill magnet, greased plate, amalgamated copper plate.

Methods of testing sands are outlined and the complete tree of a process for examination of black sands in commercial work is given. Tables are then given of the results of concentration of sands from various localities.

The horse-power of the different concentrating machines used at the tests in Portland is given, but the amount of sands which each machine is able to treat in a certain time appears not to be stated. The cost of concentrating black sands on the Pinder table is estimated by Mr. J. Andrew Wauchope as 4.2 cents per ton, and by Capt. J. W. Pinder as 7.4 cents per ton. Mr. Arthur Goodall's estimate of the cost of concentration on Woodbury or Willfley tables is 6.6 cents per ton, and Mr. A. W. Park's estimate on Wilfley table (omitting cost of water), is 3.9 cents per ton

The Mine & Smelter Supply Co. has furnished the following estimate for a small plant for treating black sands, the first estimate being for ordinary gravel, too coarse for use with the sand pump, the second where the sand pump is substituted for an automatic feeder

Estimate of Cost of Plant for Treating Black Sands.

One standard type challenge ore feeder, complete	$80.00
One 6-inch bucket elevator, 20-foot centers, complete, with all necessary head irons, foot irons, and cast-iron elevator boot, necessary best grade of rubber belt, pressed steel buckets and bolts	111.75
One revolving Trommel screen, 24-inch diameter by 6 feet long, complete, with sheet iron housing, screen covered with 10-mesh, No. 18 steel wire screen	117.00
One revolving Trommel as above, except covered with 30-mesh, No. 28 steel wire screen	100.00
One No. 5 latest improved Wilfley table complete, with middling elevator	450.00
One 9-hp Stickney gas engine, complete, ready to run	375.00

For plant using 2-inch centrifugal sand pump in place of feeder and elevator deduct price of feeder and elevator, or $191.75, and add the price of:

One 2-inch Card & Weber centrifugal sand pump, with chilled iron side plates and runner	90.00

Twenty feet of 2-inch pipe with elbow and 12 inch long nipple for delivering material into screen....	$3.00
Shafting, pulleys, boxes, collars and belting, in either of the above estimates, approximately.....	70.00

Electric Smelting.

The concluding part of the publication is the report of Dr. David T. Day, Mr. C. E. Wilson and Dr. G. Howell Clevenger on electric furnace experiments.

The first series of experiments was carried out by Mr. Wilson and was intended to produce steel in one operation from the black sands in the electric furnace and to determine to what extent the titanium usually found in the magnetite might effect the smelting process.

The design of the smaller and larger furnace used by Mr. Wilson has already been given in detail on page 5 of our Vol. IV. A considerable quantity of metal was produced in this first series of experiments. But "the product varied greatly, and, apparently, there was absolutely no control over the work of the furnace. Runs upon the same raw material would, in some cases, show low phosphorus and other runs would show high phosphorus. The same was true of the sulphur and the carbon, the carbon ranging from that contained in medium steel to that contained in white iron. In some cases, chemically, the product appeared to be good. Invariably the product was poor physically, being full of blow-holes."

Dr. G. Howell Clevenger, formerly associate professor of metallurgy in Stanford University, was engaged later on to extend this first series of experiments. His discussion of the results of the above mentioned first experiments is as follows:

"A process to produce steel direct from the ore would have to provide for the following requirements: 1. Reduction of the metal from the ore. 2. Oxidation of surplus carbon and impurities. 3. Deoxidation and killing. A consideration of the report on the first series of experiments shows that it is impossible to fulfill these requirements at one operation, as the conditions necessary for each are directly opposed to one another.

"All the slags made in these first operations were very ferruginous and consequently highly oxidizing. This is the case even with considerable excess of reducing agent and with sufficient lime to satisfy the acid constituents of the charge. This is due to the fact that the ore at once comes into the smelting zone and becomes melted before the iron is thoroughly reduced. Thus it will be seen that by this method requirements one and two are but imperfectly carried out, and absolutely no provision is made for requirement three.

"Reduction is very imperfect, as is indicated by the high iron content of the slags. Oxidation is irregular and uncertain, as is indicated by the erratic elimination of sulphur and phosphorus and the great variation of the carbon content when smelting the same charges and under the same conditions.

"As is well known, a very strong reducing action and a high temperature are necessary for the elimination of sulphur. Phosphorus may be eliminated by a ferruginous slag under proper conditions, but at a high temperature metallic iron reduces phosphorus from this type of slag. Thus the phosphorus passes back into the steel, even if once removed.

"In many cases the high carbon content of the metal was caused by absorption of carbon from the lining of the furnace. This theory is supported by the furnace tapping itself upon one occasion just as one of the charges was completely melted down. This metal was low in carbon, while charges run upon the same material, which were allowed to remain in the furnace for a time after fusion, were high in carbon.

"Deoxidation and killing is not provided for at all, the metal being tapped while in contact with the highly oxidizing ferruginous slag. This accounts for the large number of blow-holes and the general unsoundness of the metal. Summing up this method of working, it is imperfect as regards reduction of the iron and oxidation of the impurities, and further deoxidation and killing of the metal are not provided for at all.

"And yet, notwithstanding the apparent very great weakness of this method, it is possible that, so far as electric smelting is concerned, it may prove the best practice where steel is the final product desired. Thus, during the reduction by sacrificing a portion of the iron, much of the carbon and other impurities can be kept out of the metal, and the further refining of the metal can be much more quickly accomplished than where the iron is completely reduced from the ore, in which case it contains the maximum amount of carbon and other impurities. The deciding point between these two methods of working would be whether it was more advantageous to allow a portion of the iron to go to waste or to expend more energy in refining the final product. Of course, in this connection, the total amount of energy used in either case must be considered; that is, reduction plus refining in each case."

In the second series of experiments, carried out by Dr. Clevenger, the process was divided into two steps; first, iron smelting and, second, steel making.

The general plan of operation was that the first smelting operation should be carried on in a furnace of the type used for the first experiments. In this furnace the metal would be reduced and part of the impurities removed, the molten metal being tapped into a second furnace without carbon in the lining, the current entering by one movable electrode and passing out through another. In this furnace oxidation could be finished and deoxidation and killing could be carried on to any degree desired.

The dimensions of the first furnace for smelting were: Bottom plate, 60 x 72 x 3 inches; shell, 60 inches in diameter and 60 inches in height; carbon crucible, 20 x 20 x 31 inches; thickness of sides of crucibles, 4 inches; of bottom, 28 inches; size of movable electrode, 10.5 x 10.5 x 38 inches.

The other furnace was of the Héroult type, designed to use two 4-inch electrodes. The lining was finely crushed chromite, held together by fireclay. This furnace was placed so that the metal could be tapped into it from the reduction furnace.

The first run was made in the reduction furnace upon magnetite, separated by a Dings magnetic separator from beach sand from the mouth of the Columbia River. During the first run the furnace equipment showed general weakness, and it was thoroughly demonstrated that carbon as a lining for the sides of a furnace of this type is not satisfactory. "When the furnace is cold, as in starting up, there is no difficulty if the electrode is kept centered; but as the furnace becomes hotter and becomes filled to a greater or less extent with metallic vapors, the arc will leap a longer distance, and the result is that the arc occurs at intervals between the sides of the furnace and the electrode."

In the next runs the carbon sides of the crucible were replaced by silica brick, and changes were made in the electrical connections to the furnace. But on account of the conditions under which the experiment was carried out, difficulties were again experienced which made it impracticable to use a high column of charge in the furnace, and it was found necessary to maintain an arc between the surface of the bath and the electrode, to feed in the charge a very little at a time, and thus to have absolutely no column of charge.

During these experiments 152 pounds of iron were produced with an expenditure of electrical energy estimated as 560 kw-hours (on the basis of an assumed power factor of 0.7). The iron produced was close-grained gray iron of remarkable toughness, containing 1.81 per cent Si, 0.07 Mn, 0.386 P and 0.012 S.

The electrode for this run was ordinary carbon, 10.5 x 10.5 x 36 inches; 51 pounds of the electrode were consumed. It lost in length about 2 or 3 inches, but had become pointed. This would account for the apparently large loss in weight for the quantity of iron produced. "It is the tendency of these electrodes to become pointed; hence they should be molded pointed in order to avoid to a certain extent this extra loss on a new electrode. The starting and the stopping of the

furnace, especially the stopping, are by far the hardest items of the run upon the electrode." Dr. Clevenger, therefore, considers the results of electrode consumption obtained from short runs to be misleading and invariably high. "As a result of the experience with the electrode of the first run, which was badly cracked and shattered when first heated up, all electrodes used in subsequent experiments were annealed before using—that is, they were heated until all moisture had been driven out of them. The electrode used in the second run was thus treated, and showed only a small amount of cracking, which did no damage."

At an early stage of the smelting the portion of the electrode exposed to the air became coated with slag and fine particles of charge thrown up from the furnace by the boiling. This protected the electrode from the action of air, and as a result the whole electrode, except at the point, remained intact.

The silica lining of the furnace was in places almost entirely eaten away. This was caused by the basic nature of the slag, due to the large quantity of iron it contained. This is due to the method of smelting with a shallow bath and no column of charge. The magnetite under this condition of operating is not completely reduced to metallic iron before it reaches the smelting zone, and hence it attacks the silica lining. The slags obtained by this method of working are invariably high in iron and very heavy.

Alterations in the equipment were again made for the next run. The furnace was lined with an acid lining made from crushed quartz, with 10 per cent of fireclay to bind it. This lining was round. Round 8-inch graphite electrodes were used instead of square carbon, and a new electrode holder was designed. The electrical connections to the furnace were also again changed. The charge consisted of 500 pounds Wyoming magnetite (passing ¾-inch ring and containing 83.4 per cent ferric oxide and 14.1 titaniumoxide), 100 pounds charcoal, 15 pounds limestone and 5 pounds silica (99 per cent pure quartz).

The current was turned on and after running for about 5 minutes the charge was filled up to the top of the furnace. "Everything ran smoothly for several hours, then trouble commenced to be experienced by the charge partially fusing and hanging at the top of the furnace. At first this trouble could be remedied to a certain extent by working down the charge by means of raising and lowering the electrode. Later stoking down with iron bars had to be resorted to.

"After the furnace had been running for some time much trouble was experienced by violent boiling of the charge. This caused a great loss of efficiency in the furnace. This was caused probably by the small section of the furnace at the slag level and the fineness of the charge."

During the run six charges of Wyoming ore were run and four charges of black sand briquettes of 500 pounds each.

The briquettes were made up of 500 pounds magnetite fines, 100 pounds charcoal, 40 pounds lime and 50 pounds fireclay.

The total time of the run was 36 hours. The total iron in the charge was 2,583 pounds, and the total iron produced 2,246 pounds, so that 337 pounds of iron were lost in the slag. The energy consumption amounted to 3,760 kw-hours per 2,000 tons of pig iron. The consumption of the graphite electrode during the run amounted to 205 pounds.[1]

The iron produced varied from white to gray. The analysis of one typical specimen of gray iron was 0.03 Si, no Mn, 0.074 P, 0.005 S, 4.3 total C, 0.530 Ti, 0.090 Cr.

The consumption of electrical energy per ton of pig iron produced is not so good as indicated by some other recently published figures[1]; "but this is due to the high titanium content of the ores smelted, which necessarily requires more power to reduce, to the short duration of the experiment, and to the very irregular working of the furnace a part of the time.

"A very noticeable feature was the extraordinary consumption of electrode. There seemed to be very little tendency for the slag to form a protective coating upon the graphite electrodes, as in the case of the carbon electrodes. As a partial explanation of the heavy electrode consumption the following is offered: Conductors carrying heavy currents are surrounded by strong lines of magnetic force. This was very forcibly shown in this case by the attraction of iron bars and shovels when held near the cables carrying the secondary current, or near the graphite electrode. When the charge is fed into the furnace, the fine particles of magnetite are attracted by the electrode. Thus it is constantly surrounded by this material, which, when it becomes heated to a high temperature, becomes a very strong oxidizing agent; hence the rapid destruction of the electrode."

The steel furnace in which the iron reduced in the first furnace was to be treated had a lining of crushed magnetite and tar. The original idea of tapping the molten metal from the first furnace into the refining furnace had to be abandoned on account of the fact that not enough current was available to run both furnaces at once. While the experiments show the possible elimination of impurities, the report does not indicate that any conclusive results were obtained. It is said that much difficulty was experienced in getting proper refractory material.

* * *

The results of these electric furnace experiments are disappointing in so far as they have not yielded any definite quantitative results; on the contrary, former investigations by other investigators, especially with the Héroult furnace and with the Colby-Kjellin induction furnace, have given far more important and concise information on electric smelting and refining than were obtained at Portland. But the Portland research was evidently not made for such a purpose.

The report of Dr. D. T. Day and Prof. R. H. Richards is undoubtedly a valuable contribution to the literature on black sands. It is a conservative document, and in view of our former criticisms (our Vol. IV., p. 339 and 469) of unofficial or semi-official accounts of the Portland experiments, it is only fair to state here that the official report contains nowhere the ridiculous claim (or anything like it) that the Portland experiments have shown that steel can be made from black sand for $12 per ton.

[1] A comparison of these figures with the results obtained at Sault Ste Marie with the Héroult furnace (Dr Haanel's report, our Vol. IV., page 265) seems interesting. At the Soo the electrical energy required for the reduction of 1 ton (2000 lbs.) of pig iron was 83 hp.days or 1185 kw-hours, which is less than four-tenths the energy consumption given above (3760 kw-hours) for the Portland experiments. The electrode consumption at Portland was 205 lbs. per 2246 lbs of iron produced, or 182 lbs. per ton of iron, which is more than ten times the electrode consumption in the Soo trials (17.98 lbs. per ton).—Editor.

The "Pinsh Effect."

A very interesting paper was presented by Dr E. F. Northrup (of the Leeds & Northrup Co., of Philadelphia) on March 2, before the American Physical Society, at Columbia University. The paper relates to certain forces which exist in the interior of an electric conductor, and which manifest themselves at high current densities if the conductor is liquid, and therefore susceptible to deformation.

The fundamental observation was made by Mr Carl Hering, when a relatively large current was passed through a horizontal liquid conductor. The liquid seemed to disobey the ordinary laws of gravity by flowing up-hill onto the electrodes, and standing at rest with its surfaces at steep angles of 45° and over. The liquid acted as though the column were forcibly contracted in cross section.

Dr Northrup has developed the theory of the phenomenon and confirmed his formulas by experiments. The gist of his argument is that the current elements near the outer surface of the conductor tend to move toward the center across the lines of force which are in the conductor itself. This tendency is exactly the same as that of any conductor carrying a current which tends to move across lines of force.

The Butters Slime-Filter at the Cyanide Plant of the Combination Mines Company.*

By Mark R. Lamb.

The slime at the Combination Mill at Goldfield, Nev., averages perhaps $20.00 per ton and for its treatment the canvas-cell filter is used, developed by Chas. Butters and his staff. By the use of this filter slime can be treated at a lesser cost and with a higher percentage of gold—or silver—extraction than in the ordinary treatment of sand, and, moreover, the initial outlay for an all-slimming plant is less than that for the ordinary sand and slime plant.

The economy of construction of the Butters filter plant is clearly shown in Figs. 1 and 2, which illustrate the 20-frame filter of 40 tons capacity now being installed by the Nevada

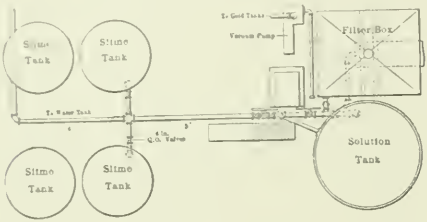


FIG. 1.—THE 20-FRAME FILTER OF THE NEVADA GOLDFIELD REDUCTION CO. (PLAN.)

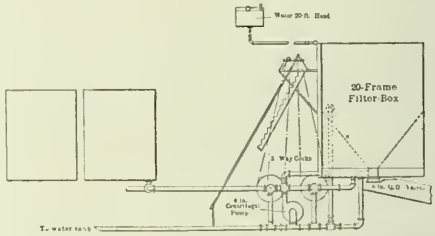


FIG. 2.—THE 20-FRAME FILTER OF THE NEVADA GOLDFIELD REDUCTION CO. (SIDE ELEVATION.)

Goldfield Reduction Co. In this construction the slime pump is so connected that it can pump to or from either tank or the filter by changing the valve settings—a combination which is necessary in this particular installation, since sufficient fall is not available for filling and discharging the filter by gravity.

Ordinarily, a slime plant comprises a filter box with frames or cells, two tanks of double the capacity of the filter box, for slime and water, respectively; a "wet" or "dry" vacuum pump, or other source of vacuum; a centrifugal slime pump, and a series of agitation tanks, which also provides storage for the slime. With regard to the economy in labor required to operate the Butters filter plant, 500 tons of slimes, or even more, can be treated, filtered and discharged by one man per shift—a remarkable gain as compared with ordinary practice in filter pressing.

Where the filter is installed to replace treatment by decantation, no extra tanks are required, and the necessary additions are merely the filter and a source of vacuum. Furthermore, the unused settling and treatment tanks can be used as treatment tanks, thus increasing the time of treatment, if desirable, and also increasing the capacity of the plant.

The cycle of operations is as follows: The slime, after agitation in solution the required time, is pumped into the filter box. As soon as the latter is full the filter is connected to the source of vacuum and the gold solution drawn from the pulp through the canvas of the cells, while the slime forms a layer on the outer surface of the canvas. While the slime cake is being formed the filter box is kept full of slime pulp by pumping it in as fast as solution is drawn out through the frames.

When this layer is of suitable thickness (which depends on the permeability of the slime) the vacuum is reduced to a pressure barely sufficient to hold the slime in place, and the pulp still in the filter box is returned to its storage tank. The centrifugal pump is set to fill the filter box with water, the vacuum is raised, and the slime cake is washed. This water, which passes through the filter, is sent to the gold tank. When desirable the slime can be given a wash with solution before washing with water. This will be done at the Nevada-Goldfield plant.

When all dissolved metal is removed from the cake it is dropped from the canvas by merely breaking the vacuum and turning water or water and air into the cells under a pressure of about 10 pounds per square inch. A period of 5 minutes suffices to drop the slime. Surplus water in the filter is then drawn off, if the saving of small quantities of water is desirable, and the bottom discharge valve opened. The slime, containing from 20 to 40 per cent of moisture, is discharged in less than a minute.

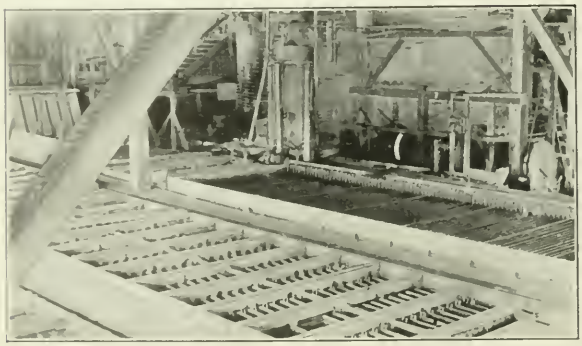


FIG. 3.—THE 20-FRAME FILTER BOX AND ELECTROLYTIC PRECIPITATION VATS AT VIRGINIA CITY PLANT.

The time required for the treatment of one lot of slime is about 3 hours, depending upon the thickness of the cake, the size of the slime pump and the permeability of the material—all matters which can be determined in advance. The filter is used six or eight times in 24 hours. Correctly speaking, the slime is not treated in the filter, since agitation and extraction of the values take place before the filter is reached. In other words, the filter is used solely to displace the metal-bearing solution. In Mexico, the filter is handled by one Mexican peon per shift. These peons learn quickly and are entirely satisfactory.

One of the most important and vital features of the filter is the fact that the regulation of the thickness of the layer of slime depends upon its permeability. Thus, if fine sand is mixed with slime it tends to collect on the bottom of the center cells (which are directly over the inlet from the pump) in a proportionately thicker layer, thus causing all parts of the layer of slime to be equally washed.

The economy in time for complete displacement by the Butters filter (from 15 to 20 minutes, see Table I.) is plainly evi-

* An Am. Inst. Min. Eng. paper, slightly abstracted from the January issue of the Bi-Monthly Bulletin of the Institute.

dent when compared with the usual practice, using a press or by decantation. The Virginia City plant of Chas. Butters & Co. is now treating ores from Tonopah, the slime of which settles very slowly. The pulp is brought to the plant with about 100 parts of water to 1 of slime, which condition will be changed shortly, but which now makes a secondary de-

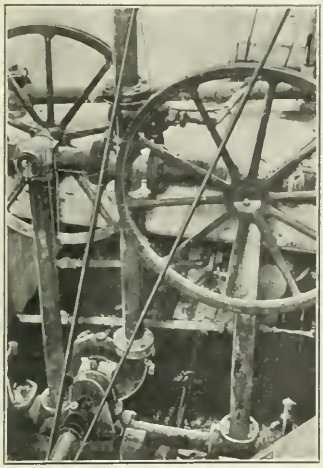


FIG. 4.—SLIME PUMP, THREE-WAY COCKS, VALVES AND PIPING AT COMBINATION PLANT.

watering filter necessary. This latter device works well, and but for it the slime could not be treated except with a large loss of solution.

According to the paper by Charles Butters and E. M. Hamilton, entitled "On the Cyaniding of Ore at El Oro, Mexico, Dealing Principally with Regrinding of Sands,"[1] describing practice at El Oro, Mexico, slime can be made of sand at a cost of $0.53 gold per ton. The cost at the Combination Mill is a little less than this figure.

It is rarely the case that the difference in value between sand and slime tail assay would not exceed this amount, and including the occasional (?) slimy sand tank, with which the cyanider must contend, calculation will show that many plants could largely increase profits by slimming the entire product.

Fig. 3 is a view in the Virginia City plant, showing the electrolytic precipitation vats in the foreground, directly in front of a 90-frame filter box, which has a capacity of from 150 to 200 tons per day.

Fig. 4 shows the slime pump, three way cocks, quick-opening valves and piping at the Combination plant, which arrangement, as previously explained, is necessary only where sufficient grade is not available.

Fig. 5 shows the end view of the lower half of the filter box, and at the right-hand side the geared vacuum pump.

Fig. 6 shows one leaf of the filter, which has lines of stitching in order to resist the internal pressure

Fig. 7 is a perspective view of a plant of 100 tons daily capacity, comprising filter box, slime and water storage tanks above, the slime storage tank below, the vacuum drum connected to the filter leaves and to the gold sump and the gold solution and slime pumps.

Fig. 8 is a detail view of the filter box shown in Fig. 7, with filter leaves in position, some shown in section and some removed.

The list of tests, made to show results which were being attained at the Combination plant,[2] is given below.

It should be explained that "water" wash was, in reality, solution assaying $0.60 per ton, which would otherwise be waste solution. This water, as it is drawn through the slime cake, does not go to the zinc boxes, but is used to replace the weak wash which is precipitated. The weak wash assayed $4.02 per ton.

TABLE I.—SOLUTIONS FROM A CAKE 1.25 INCHES THICK.

Weak Wash.

Time.	*Value Per Ton.*
After 2 minutes.	$12.22
" 4 "	12.20
" 6 "	11.89
" 8 "	11.96
" 10 "	11.40
" 12 "	10.90
" 14 "	8.90
" 16 "	6.82
" 18 "	4.76
" 20 "	4.40
" 22 "	4.26
" 24 "	4.12
" 26 "	4.10
" 28 "	4.02

Water Wash.

Time.	*Value Per Ton.*
After 5 minutes.	$3.66
" 10 "	3.62
" 15 "	3.12
" 20 "	0.60
" 25 "	0.60
" 30 "	0.60

The practice at the Combination Mill is to wash from 16 to 18 minutes with solution and the same length of time with water.

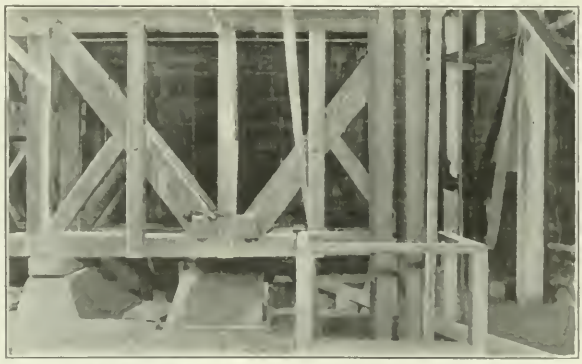


FIG. 5.—END VIEW OF LOWER HALF OF FILTER BOX, WITH GEARED CENTRIFUGAL PUMP AT THE SIDE, COMBINATION PLANT.

The ordinary slime-settling device, whether tank or spitzkasten, rarely produces a product with less than 60 per cent of moisture, and in many cases the proportion is three or four

[1] Institution of Mining and Metallurgy, Vol. XIV, pages 3 to 46 (1904-05).

[2] Engineering and Mining Journal, Vol. LXXXI., pages 1,236 to 1,238 (1906).

tank. This water must necessarily dilute the cyanide solution added to the slime, or, in case cyanide is added to the slime without further addition of solution, this solution, after precipitation, must be run to waste. Of course, the ideal way is to mill in solution, though for other reasons this is not always desirable.

When milling in water, by a proper arrangement of pipes and valves, and by providing a filter of sufficient capacity, the settled slime can be dried to any economical degree of moisture, and by filling the filter box with solution the slime can be pulped again by means of the centrifugal pump and returned to the agitators, thus avoiding the necessity of making solution which must be run to waste.

As an example of what can be done, 100 tons of slime, if treated without removing the water, will cause the loss of about 75 tons of weak solution, containing about 0.8 pounds of KCN per ton, or 60 pounds. If the Butters filter is used this loss can easily be reduced to 8 pounds without additional expense.

Particular attention should be paid to the thoroughness of the wash. After 20 minutes, if pure water be used, the wash-water from the slime at the Combination Mill shows no measurable quantity of cyanide.

The quantity of solution made by washing is much reduced

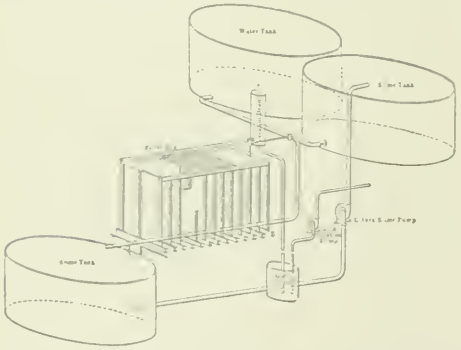


FIG. 7.—VIEW SHOWING ARRANGEMENT OF A 100-TON SLIME FILTER.

in volume when compared with the amount necessary for washing a filter press charge. In fact, the wash-water will about make up for evaporation losses when ore is milled in solution.

Experiments are now under way with a view of doing the entire treatment on the filter, thus saving tankage and time. These experiments will only succeed with ores such as that treated at the Homestake slime plant, where extraction from slime is almost instantaneous. Such treatment would not succeed with a silver ore, for example, where long agitation and aeration are required.

I feel confident that this filter will be the cause of many plants abandoning entirely the treatment of sand, thus reducing the cost of installation, depreciation and operation, and increasing the capacity and the extraction.

Atomic Weights.—The report of the International Committee on atomic weights for 1907 has been published in the February issue of the American Chemical Society. Important changes are: Nitrogen, from 14.04 to 14.01; bismuth, from 208.5 to 208.0; tantalum, from 183 to 181; terbium, from 160 to 159.2. The atomic weight of silver, as deduced from Stas' data, is probably too high, but by an unknown amount.

The Electric Furnace in the Pottery Industries.

At a recent meeting of the English Ceramic Society, Dr. R. S. Hutton, of the University of Manchester, presented an interesting lecture, with demonstrations, on electric heating and its application to the fusion and firing of refractory materials. The electric furnace served at first solely for the initiation of new industrial processes, demanding temperatures quite beyond the scope of fuel heating. But now electric heating is being widely applied in cases where the temperatures required are just within the limit attainable with gas or coal firing, and the general tendency is undoubtedly towards its

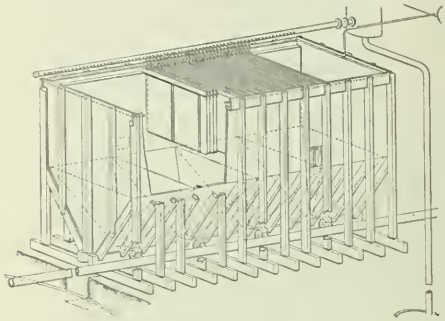


FIG. 8.—DETAIL VIEW OF FILTER BOX.

use for still lower ranges of temperature. Dr. Hutton is careful to emphasize that there is no panacea in the word electricity, and that improvements in economy and convenience are the explanation of the extended use of the electric furnace beyond its original high-temperature sphere. As a matter of fact the success of the application of electric heating often depends more on the appalling inefficiency, due to the wasteful employment of coal, in the process being displaced than upon any intrinsic advantage of electric heating.

The chief advantages of the application of electricity for heating are: 1, that it enables the heat to be generated just where it is required—inside rather than outside the heating chamber; 2, the simplicity of a delicate regulation of temperature; 3, the ease with which the furnace or kiln can be provided with a really efficient heat insulation, capable of economizing the thermal losses to the outside air.

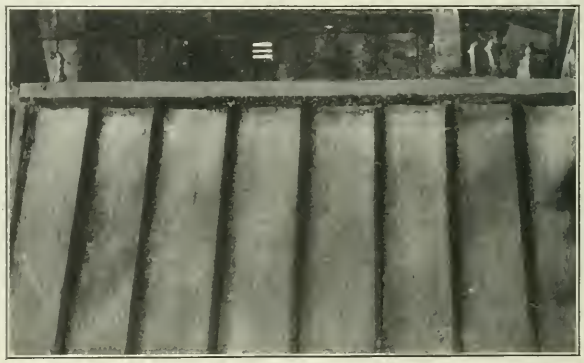


FIG. 6.—ONE LEAF OF THE FILTER, SHOWING REINFORCEMENT BY STITCHING, COMBINATION PLANT.

Dr Hutton's paper makes suggestions as to what might be hoped from the electric furnace in the pottery industry, and

discusses in the first part the use of the electric furnace for experimental work in the laboratory of a pottery. The principal object would be a thorough and methodical experimental study of the changes in the physical properties of the various oxides and other bodies which enter into the composition of their raw materials, caused by a variation in the temperature at which they have previously been fired.

Something has already been done in this direction. Dr. Hutton mentions the work of A. Ditte on magnesia (*Comptes Rendus*, 73, 111, 191, 270, 1871), and H. Le Chatelier on silica (*Comptes Rendus*, 111, 123 to 126). Some more recent work on magnesia[1], magnetic oxide of iron[2] and alumina[3] is interesting, as it shows how very greatly the properties of these materials are altered by exposure to high temperatures in the electric furnace. In the case of alumina at least application has already been made to the ceramic industry.

Another application for which the electric furnace is specially suitable is the determination of the temperature at which a ceramic material fuses or, perhaps, rather, the determination of the point at which the material begins to soften and lose its shape.

As electric furnaces suitable for laboratory work of this kind some simple types of resistance and of arc furnaces are described by the author. Among the resistance furnaces he distinguishes between such with metallic heating wires and such with carbon resistors. In the latter solid carbon, for instance, in form of carbon tubes may be used, or the carbon may be applied in granular form so as to surround the heating chamber. The granular carbon should be ground, sieved and graded; the heating being much more uniform if the grains are approximately of the same size. Furnaces of this type have been widely adopted; at the Berlin Porcelain Works they have been used up to about 1,700°. (M. Simonis and R. Rieke, Sprechsaal, 39, 589 to 591, and 633 to 635, 1906.)

In the second part of his paper Dr. Hutton reviews several industrial electric furnace processes. He first speaks of carborundum and siloxicon. He mentions the work going on in Niagara Falls, tending to put the manufacture of bricks, crucibles, etc., of siloxicon on a commercial basis. Much attention has also been given of late to the problem of agglomerating the powdered carborundum with a view to making strong vessels of this material. (See F. A. J. FitzGerald, Carborundum, Halle, 1904; Carborundum Co., Eng. Pat. 9,963, 1904; E. G. Acheson, U. S. A. Pat. 722,793, 1903; L. E. Muller, French Pat. 329,232, 1903; Gebr. Siemens, Eng. Pat. 21,347, 1905.) Amongst other similar uses the lining of the kilns with bricks coated with a thin layer of carborundum may be mentioned.

After a few notes on artificial graphite the author gives a review on the fusion of alumina. The object of this work, in the first place, was the production of artificial rubies. After much painstaking work, in which other French scientists have taken part, Verneuil has succeeded in producing fairly large masses, and has recently described his most ingenious method of working. (Verneuil, *Ann. Chim. Phys.* [8], 3, 20-48, 1904. For historical account see H. Marour, *Revue Chim. pure et app.*, 6, 72-77, 1903.)

The author then referred to the very successful commercial work of the Norton Emery Co., who produce alundum, that is, artificial emery, made by fusion and purification of alumina in the electric furnace. At Rheinfelden a similar product is being manufactured, but is called "Diamantin." The Goldschmidt Thermit Co. is also employing as an abrasive the fused alumina, which occurs as a by-product of the processes which they carry out. (See footnote 3 above.)

In this connection is to be mentioned the application of fused alumina to the production of a new "pottery body." This development has been carried out by an important German firm of potters (Deutsche Steinzeugwaarenfabrik, of Friedrichsfeld) in conjunction with a leading chemical works. (See footnote 3 above.) The different articles made from this new material are said to possess to a remarkable degree the power of withstanding sudden heating to a high temperature. This is due to the very small contraction which occurs in articles made with suitable mixture of the fused alumina and clay.

It would indeed be of interest to know the relative behavior of other completely "shrunk" oxides, etc., when used in a similar manner; by actual fusion in the electric furnace these materials can be obtained in a condition in which subsequent heating causes no further contraction. The strength of bodies made of such materials when subjected to severe thermal treatment probably depends much more upon the completeness of this "shrinking" than upon the thermal conductivity.

Dr. Hutton then speaks about magnesia. Since magnesia is the most refractory of the commonly occurring oxides, it is surprising that it is not more widely employed for the construction of vessels capable of withstanding high temperatures. Up to the present, however, ordinary calcined magnesia has been found none too well suited for this purpose. Magnesia bricks, crucibles, etc., of nearly all makes require very great care in handling, and it is particularly necessary in furnace work to heat them evenly and slowly, otherwise fracture occurs.

Recently the electric furnace has been used to fuse or shrink magnesia (see E. K. Scott, our Vol. II., p. 454; Vol. III., p. 140), and much may be expected by the application of such products for the manufacture of crucibles, etc.

Pure magnesia tubes and other vessels of small size are now made by the Royal Porcelain Factory, at Berlin, but on account of their high cost are obviously of greater importance for scientific than for technical work. There is, however, nothing to hinder the cheap production of electrically shrunk magnesia on a large scale, so that further developments along these lines may confidently be expected.

Arc furnaces very similar in general type to those employed in the manufacture of calcium carbide have been used technically for the production of fused alumina and magnesia, and, where it is desirable to produce a really fused and liquid product, there are somewhat great difficulties in the way of using a resistance furnace with material packed around a central core. On the other hand, much can be done with resistance furnaces, and large masses of magnesia can be heated to near the melting point, and caused to recrystallize with a very simple type of furnace, and with considerably lower power expenditure than is incurred with the arc type of furnace.

The author finally made a few remarks on what he calls silica glass, or what is called by others fused silica or fused quartz. The manufacture of this product has within the last few years shown signs of developing into a flourishing little industry.

The quartz fibers of Boys were followed by the tubes and small vessels of Shenstone, but in both cases it was the oxy-hydrogen blow-pipe which served as the source of heat. The working of the material was consequently both tedious and expensive.

[1] Paper by H. M. Goodwin and R. D. Mailey, our Vol. IV., page 216.

[2] In our Vol. III., page 392, a patent by H. Specketer, assigned to the Griesheim Elektron Company, was mentioned. He melts in the electric furnace ferric oxide, to be used in form of electrodes which are said to be specially suitable for chloride electrolysis. According to private reports received, these electrodes are now used on a large scale in Germany, and are proving successful. The chief advantage over carbon electrodes is said to be that the chlorine developed is free from carbonic acid. It is also said that a certain disease of workingmen which was attributed to the volatilization of certain substances used as binding materials in the carbon electrodes, has ceased since the introduction of the ferric oxide electrodes.—Editor.

[3] Dr. M. Buchner has done important work in this direction, as was first noticed in Dr. Hans Goldschmidt's Electrical Congress paper, our Vol. II., page 405, on the use of corubin (the pure alumina slag from the thermit reaction of production of metallic chromium) for vessels which can be suddenly heated or cooled without danger of cracking. The same "Buchner patent material" is also used for diaphragms, as noticed in our Vol. IV., page 337. See also M. Buchner, "Zeit. f. Angew. Chemie," 17, 985 to 988, 1904, and "Chemical Trade Journal," 35, 398, 1904.

Recently the electric furnace has been called into service with more satisfactory results. Relatively large tubes have been obtained from quartz crystal of Calais sand, both by indirect heating with the electric arc and also by passing the electric current through a carbon core surrounded by sand. (R. S. Hutton, *Mem. Manch. Lit. and Phil. Soc.*, 40, VI., 1–5, 1901; *Trans. Amer. Electrochem. Soc.*, 2, 105–111, 1902; our Vol. I., p. 58.) "Recently the electrical process has been developed, and a method discovered for blowing and shaping vessels from the semi-fluid material produced around an electrically-heated core. (Eng. Pat., 10,070, 1904.) With these and other improvements the Thermal Syndicate, of Wallsend-on-Tyne, is producing large pipes, bricks, dishes, insulators, pyrometer tubes and a variety of other ceramic articles."

The advantages of fused silica are its low coefficient of expansion, its highly refractory nature and its extreme hardness. In the discussion which followed, Dr. J. W. Mellor said that the properties of fused silica reminded him of fireproof china, "and some of us, on the morrow, will no doubt try how this substance will work in pottery bodies." He also had no hesitation in saying that the electric furnace opens up great possibilities in the preparation of "a new palette of pottery colors."

Electrochemical Problems.

In our last issue, page 41, we gave the first part of a list of problems on subjects bearing on electrochemistry, some of which, it is intended, shall be discussed at the next general meeting of the American Electrochemical Society in May, in Philadelphia. We herewith give the concluding part of this list of problems.

The study of the law of energy in electrochemical reactions; including the disputed question whether, in electrochemical decompositions that compound will first decompose which requires the least energy to decompose it. Also including the question whether a compound can be decomposed with a voltage less than that required by theory, from the energy of decomposition.

When a horizontal anode is placed about a half or quarter inch above a layer of mercury and in a solution of acidulated zinc sulphate, the mercury being the cathode, hydrogen will be evolved freely from the mercury at moderate current densities; when the current is then increased, a point will be reached when no trace of gas is evolved immediately below the anode (which should be smaller than the cathode), while outside of this area there will be free gasing. What is it that takes place over the non-gasing area, and can it be used for the deposition of the zinc in the mercury without the evolution of hydrogen?

A study of the thermo-electromotive forces between solids and liquids. They are very much greater per degree than those between solids.

The heat conductivities of linings for electrical furnaces. The temperatures and conditions under which the linings of electrical furnaces become electrically conducting; and the specific resistances under those conditions and at those temperatures.

Electrolysis without electrodes. Is this possible, and if so, what is it that takes place, and where?

In the electrolysis of acidulated water, when using the same anode, it will require widely different voltages to set free hydrogen with different metals for the cathode; it will be least when this metal is platinized platinum, and quite great when it is mercury. The excess of voltage over that in the former case has been called "over voltage." What is the seat of the energy represented by this excess of voltage? What does this energy do, and in what form is it after the reaction?

If a glass tube is filled with an electrolyte in solid form and provided with electrodes at both ends, and if, by the application of heat to one end, this electrolyte becomes a liquid at only one electrode, at what place will the electrochemical reaction, corresponding to that at the other electrode, take place if the electrolyte is of such a nature that it changes gradually from the solid to the liquid state, passing through a semi-liquid state? It cannot take place in the solid part, and there is no definite line of demarcation between the solid and liquid parts, yet it must take place somewhere, as a unipolar electrochemical reaction is unknown.

If an electrode of zinc and another of amalgamated zinc be placed in a solution of zinc and the electrodes connected externally, a current will flow in the external circuit from the zinc plate to the amalgamated one and zinc will be deposited in the former. What is the source of energy of this battery? It has been thought to be thermal, and that the liquid cools by virtue of this reaction, thereby absorbing heat from the air. If so, it would offer a direct means of changing the heat energy of the air into an electric current, and would seem to be contrary to the second law of thermo-dynamics.

Electrolytic production of magnesium.

Electrolytic method for determining silver in base bullion and dore bars.

What is the white substance formed on copper anodes when refining copper with a high current density and a cold solution?

Electric Steel.

In our January issue, page 25, we gave short abstracts of two papers recently presented before the Verein Deutscher Eisenhüttenleute, one by Eichhoff on the Héroult process as operated at Remscheid, and the other by Roechling on the induction furnace. Further notes on Prof. Eichhoff's paper, the original German text of which is printed in full in *Stahl und Eisen* of Jan. 9, were given in the Synopsis of our last issue, page 58. In the following we give further notes on the paper of Mr. Hermann Roechling from the original text in *Stahl und Eisen* of Jan 16:

Induction furnaces have certain characteristic features. First, there are no electrodes. Second, liquid rather than solid charges should be treated. Third, the heat is produced in the metallic bath rather than in the slag; if a specially high temperature of the slag is required, special devices must be used.

It has long been recognized that there is considerable difficulty in charging and discharging the narrow annular crucible of an induction furnace. Kjellin in Gysinge uses two tapping holes. But this has disadvantages. To overcome them the furnace used at Voelklingen is built as a tilting furnace as shown in the adjoining diagrams. The furnace is suspended so as to turn on two journals, so that when the back is raised the mouth is lowered and the furnace can be discharged entirely. The construction can be clearly seen from the illustration.

In the induction furnace like any other properly designed electric furnace, it is possible to remove sulphur and phosphorus to mere traces (some analyses of steel produced by the author show 0.02 or 0.03 or less per cent of phosphorus and sulphur). At a high temperature it is possible to maintain a liquid lime slag, almost free from oxide, upon and in most intimate contact with the steel bath. This has a strong desulphurizing effect. The author claims that manufacturers using electrode furnaces add considerable quantities of fluorspar to their lime slag in order to desulphurize the bath. He says that this has not been necessary in his own experiments with the induction furnace. Even without such an addition the slag was sufficiently fluid.

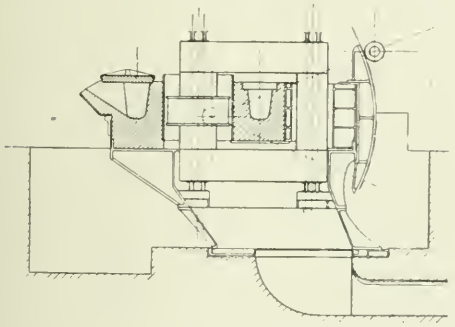
The removal of large quantities of carbon is difficult if simultaneously large quantities of phosphorus are present. The less the quantity of phosphorus in the iron the easier it is

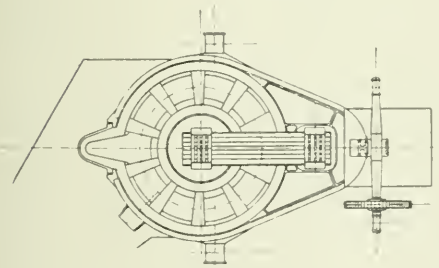
to remove the carbon. With 0.1 per cent of phosphorus there is no difficulty. It is similar with manganese and silicon.

With respect to the deoxidation of the bath, this is not possible if the slag contains any appreciable amount of compounds of iron and oxygen. Such a slag must therefore be removed. At Voelklingen, powdered lime is then simply added to the bath to form a new slag. If necessary this is repeated with simultaneous addition of reducing agents and a complete deoxidation is obtained.

The experiments in Voelklingen were made with two furnaces, one containing 50 to 60 kg. (110 to 130 pounds), and the other 300 kg. (660 pounds). Alternating current of 50 periods was used. With the smaller furnace the power factor was very satisfactory; the figure given is 0.95. For the larger furnace no figure is given; it is said that the power factor is poor, but it is hoped to improve matters.

To melt pig iron and heat it to about 1,200° C (about 2,200° F.), about 385-kw. hours per ton were required in the 300-kg. furnace. To complete a charge of scrap, about 600-kw. hours are required. The cost of this amount of electrical energy would be too high to render the process economical, and this is the reason why molten metal (instead of cold scrap, etc.) should be charged into the furnace, since in this way a considerable amount of electrical energy may be saved.



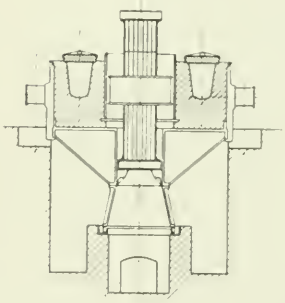


By starting with molten Thomas steel or Martin steel, it is possible to refine the bath with a low expenditure of energy. For instance, at Voelklingen it has been found repeatedly possible to completely deoxidize ordinary molten Thomas steel and to remove sulphur and phosphorus down to mere traces and to recarburize the metal to 1 or 1½ per cent of carbon and to finish the charge, with the total expenditure of 150 to 200-kw. hours per ton. With this expenditure it was possible to produce the finest sorts of crucible steel. If it is considered that this is possible with a furnace which contains only 300 kg. (660 pounds), it is evident that with a larger furnace much better results may be obtained. "The future of the electric furnace, therefore, does not rest in melting cold charges and replacing our ordinary metallurgical processes, but the electric furnace should be used rather as a supplement to our old processes in order to enable any steel plant to produce the finest qualities of steel from open-hearth steel at comparatively small costs."

To reduce the power consumption, two means are available. Either the size of the furnace is increased, to reduce the losses, or the metallurgical process is carried out as quickly as possible, since then the heat loss per unit of output will also be reduced.

The two papers of Prof. Eichhoff and Mr. Roechling were discussed together. Dr. Hans Goldschmidt gave some notes on the Stassano arc furnace. Stassano does not make, at present, steel from ore, but simply refines steel scrap. A revolving furnace of 1,000 hp. is to be started very soon.

Engineer Eilender spoke briefly about the process of Girod, which is very similar to the Héroult process, although only a single carbon electrode above the bath is used, the other terminal being a water-cooled, steel casting in the bottom of the hearth. He then criticised some remarks of Prof. Eichhoff on the manner in which the deoxidation takes place in the Héroult process. Eichhoff claims that iron carbide and ferrous oxide can exist together within certain limits in a liquid iron bath. A further deoxidation of the bath by addition of carbon would, therefore, not be possible. In the Héroult process, however, the deoxidation is carried further on account of calcium carbide being formed at the high temperature of the arc; the calcium carbide dissolves in the highly basic slag and then reacts with the ferrous oxide of the metal bath. This would, therefore, be a specific property of the Héroult process since only with this process there is a possibility of the formation of calcium carbide. Only the least traces of ferrous oxide need be rendered harmless by means of manganese. The proof that steel made in the Héroult furnace can be very much more free from ferrous oxide than any other steel rests, therefore, finally on the above assumption of the co-existence of iron carbide and ferrous oxide in the molten iron bath. Mr. Eilender does not think that this hypothesis has been completely proven by Prof. Eichhoff. The latter will discuss this matter in a separate article.



TILTING INDUCTION FURNACE.

Director Biah asked about the variations of the load during operation. Chief Engineer Engelhardt stated that they were 5 per cent in Gysinge, while Roechling said that in Voelklingen the load curve is practically a straight level line.

Prof. Eichhoff finally pointed out again that the Heroult furnace operates with one or more oxidizing slags (for removing the impurities) and then with one slag of lime and sand for deoxidation.

Jamestown Exposition.—There will be six groups of the metal and ore exhibits in the Department of Mines and Metallurgy at the Jamestown Exposition. First, structural materials and building supplies (cement and cement products, etc.). Second, hardening materials for iron and steel. Third, gems. Fourth, those minerals from which chemical compounds used in the lighting industry are derived. Fifth, clay products. Sixth, State exhibits. There will, of course, also be exhibits of mining machinery. A pavilion will be erected near the Mining Building, where all of the most approved forms of concentrating machines will be installed for determining the best methods of concentrating ores and gravels. Dr. Joseph H. Pratt will be chief of the department.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

Sampling Assay of Silver Bullion.

The first paper read before the Institution of Mining and Metallurgy at their meeting on Jan. 17, dealt with "Some Sampling Results," and was presented by Mr. E. H. Garthwaite. The question of how close, or how far apart samples should be taken is of great importance, and the author's paper throws an interesting light upon the subject. The paper is full of comparative results, and the conclusion to be drawn is that where the ore fluctuates very much in value, it is unsafe to sample at greater intervals than 4 feet, for while results from greater intervals might give a correct general average, it is not safe to trust them. It was also suggested that if samples at 1-foot intervals could be obtained, it could be definitely determined whether it would be possible safely to increase the interval to 5 feet, or better to reduce it to 3 feet.

The second paper, presented by Mr. Ernest A. Smith, described "The Assay of Silver Bullion by Volhard's Method," of which the following are the leading features:

For some years it has been the practice at several assay offices to modify slightly the ordinary method of finishing the assay by adding sufficient ammonium thiocyanate to the check assay to intensify the red color of the ferric thiocyanate and use this color as a standard of comparison. By this means the finishing point of the assay is perceived more sharply and with greater certainty than is possible when the assay is finished in the usual way by cautiously adding the deci-normal solution until the first indications of a permanent red coloration are seen. No figures showing the limit of accuracy attainable by this slight modification appear to have been published hitherto; the results of a series of experiments made by the writer, in conjunction with Mr. G. Sims, to determine this point and the best conditions of working may, therefore, be of interest to the members of the Institution. The experiments proved that, by finishing the assay as above indicated, a limit of accuracy less than 0.1 per 1.000 of silver can be obtained by Volhard's method. The following conditions of working were found to be the most satisfactory:

A "normal" solution of ammonium thiocyanate is prepared of such strength that 100 cc. is equivalent to about 1.0003 to 1.0005 grm. of silver.

On adding 100 cc. of this solution to a solution containing exactly 1 grm. of pure silver, the slight excess of ammonium thiocyanate present beyond that necessary to precipitate the silver produces, in the presence of a ferric salt, the permanent red coloration used as the standard of comparison or check.

After the addition of the normal solution the stopper is inserted and the bottle well shaken for 2 minutes; it is then allowed to stand until the precipitate settles, leaving the pale red colored solution perfectly clear. This color, as previously stated, is used as a standard of comparison, and all assays are worked to it. The addition of 0.5 cc. of deci-normal silver nitrate solution should render the solution colorless, and it is necessary to adjust the strength of the normal solution to secure this result, experience having shown that the accuracy is impaired if the color for comparison is too dark.

In assaying silver bullion (the fineness of which must be approximately known) the quantity taken is such that about 1 grm. of silver is present; it is dissolved in 10 cc. of dilute nitric acid and treated as previously described. When the liquid has cleared after shaking, the color of the solution at once shows whether silver of thiocyanate is in excess, and also indicates the approximate fineness of the bullion and the quantity of deci-normal solution required to finish the assay.

Deci-normal thiocyanate solution is carefully added from a burette until the color approaches that of the check; the liquid is then shaken and allowed to clear; after which, the deci-normal solution is cautiously run in, drop by drop, until the color corresponds exactly to that of the check. The addition of one drop (0.05 cc., equivalent to 0.05 mgrm. of silver) of deci-normal thiocyanate makes a perceptible difference to the color, which is readily recognized.

It is the extreme delicacy of the reaction between the thiocyanate and the ferric salt which is taken advantage of in the modification described, and also makes it possible to see the end of the assay with much greater certainty and accuracy than is the case when the assay is finished in the usual way. For, as Mr. Beringer has pointed out, it is the red coloration produced by the thiocyanate when the assay is nearly, but not quite, finished, and the slowness with which this is removed on shaking, that constitute the chief disadvantages of the Volhard method.

Experience has shown that equally accurate results are obtained whether the silver left in solution, after the addition of normal solution, is 1 mgrm. or 20 mgrm., or more. The comparison of the assays with the check is best made by placing the bottles so that they catch the reflected light of a white surface. A shelf with a back to which a sheet of opal glass is secured, and arranged so that it faces the direct light from a window, is very suitable for the purpose. A side light is liable to give rise to error of judgment in comparing the tints.

In addition to the importance of treating all assays under exactly the same conditions, the two most important points to be observed in working the Volhard method are the expulsion of all nitrous fumes and the thorough mixing of the liquid after the addition of the normal and deci-normal solutions. The complete expulsion of nitrous acid is very necessary for accurate work, as the color of ferris thiocyanate is destroyed by this acid at common temperatures. It is not advisable to allow the assays to stand for any long period after the addition of the normal solution, as the color of ferric thiocyanate is slowly affected by light.

In dealing with a large number of assays it is convenient to work them in batches of fifteen or twenty, according to the capacity of the mechanical shaking machine, and experience has shown that it is desirable, after adding the 100 cc. of normal solution, at once to shake each bottle by hand for a short time to mix the contents instead of allowing them to stand unmixed until the whole batch is ready for the shaking machine.

Although the Volhard method, on account of the poisonous nature and extra cost of thiocyanate, is not likely to supersede the Gay-Lussac method for commercial silver bullion assays, its greater accuracy and the facility with which the assays can be finished make it very suitable for offices in which the assay must be made with the highest attainable accuracy, and in cases where comparative tests only have to be made.

The Electron Theory in Relation to Electrolysis.

The presence of Mr. E. E. Fournier-D'Albe, as author of a paper upon "The Application of the Electron Theory to Electrolysis" (abstracted on page 52 of our February issue.—Ed.), brought several members from the country to the Faraday Society's meeting on Jan. 15. Sir Joseph Swan presided. The author enhanced the interest in the paper which he read by the able illustrative digressions made upon section after section. Sir Joseph Swan well expressed the sentiment of the meeting by regretting that a phonographic record had not been taken of the author's interpolated comments. The written words remained, while spoken words were often forgotten.

A breezy discussion was opened by Mr. J. G. A. Rhodin, who bluntly declared that the application of the electron theory to electrolysis was uncalled for, and would complicate a simple question. Why should they define a disturbing element which they could not see? He did not see the need either for a metaphysical chemistry or for chemical metaphysics. But as to the electron theory, its forerunner was Newton's theory of light corpuscles emitted from a luminous body.

In place of advancing theories, it would be better to spend more time tabulating what was known about the phenomena of solutions. The ions were too excessive a strain on our credulity—why seek to make these more complicated and enshroud the precision of chemical science in the intangibilities of an Athanasian creed?

Dr Borns inquired what the author thought of the electron theory as a whole. It was fitly regarded as an extension of the ionic theory, but he was afraid that the paper as written was a series of disjointed facts, not well interwoven. The author's explanation of mobility was difficult to follow. Also, why should it require more energy to evaporate a charged drop than an uncharged drop. Was not the electron theory rather under a cloud? Were not positive and negative electrons necessary for the Hall effect? (The author, "No"). Kaufmann's latest experiments seemed damaging to the electron theory.

Dr. Harker said that very few people had time to read elaborate books on this subject, but he must ask the author, was it his conception that was composed of a cluster of electrons, or was it the atom, a sort of solar system? Upon what did stability depend? Was the hydrogen atom, for instance, a huge mass of something with a few electrons hanging on the outside? How did mathematicians regard the electron theory? Were they to pin their faith to it, and fit their figures in around it? More Euclidean definitions were required at the start. Unhappily mathematicians wrote mainly for mathematicians. What non-mathematicians wanted was to know in simple terms the fundamental conception of the theory.

Dr. Lowry asked where the author derived his figures for the density of electrons and their diameter, also for the mean time, during which the electrons were unattached. Electrolytes have positive temperature coefficients of conductivity, but at higher temperatures these become negative. Large ions behaved as spheres moving in a viscous medium, their mobilities did not attain a definite minimum as stated, but additional viscosity in the lower values was simply the viscosity of the additional water.

Mr. Wilsmore thought that the author's explanation would lead to the clearing up of a number of obscure points in electrochemistry. Under ultra-violet light, elements tend to give off negative electrons; there was no evidence of positive electrons apart from matter. If positive electrons were entirely omitted from electrolytic equations the latter were greatly simplified. He suggested the term "negatron" in place of negative electron. Conductivity in electrolytes was probably due to negatrons. It might perhaps be that chemists rushed in where physicists feared to tread. The conception of the negative electron renders simpler the phenomena of oxidation and reduction. Mr. Wilsmore then twice covered the blackboard with the formulæ expressing chemical reactions, in the negative electrons had assigned values. A slight and reciprocally sarcastic breeze followed between the speaker and Mr. Rhodin, who intervened with comments on one of the equations.

Mr. Kaye brought the discussion back to the paper itself by asking whether different ionic mobilities did not involve different states of hydrations? He also asked whether during ebullition any movement in the electrons was assumed to take place.

In reply, the author dissented strongly from Mr. Rhodin's criticism, and declared there was the same reason for attributing mass and weight to the planet Jupiter as to an electron. He pointed out that Weber, between 1850 and 1860, pronounced an ionic theory of conduction, but this was not the "electron theory," as the carriers were supposed to be positive, and the word "electron" was coined by Dr. Stoney in 1880. Free electrons did not exist in liquids. If they did, simple consideration showed that the conductivity would be superior to that of copper, as the electrons were 100,000 times smaller than atoms. Kaufmann's experiments did not decide for or against the electron theory, but simply discriminated between Lorentz's and Abraham's mechanical structure of the electron. As regards the structure of atoms and the succession of atomic weights, the work done in this direction was almost entirely due to Mr. J. J. Thomson, who showed that atomic weights were determined by configurations of stability, and whose book on "Matter and Electricity" should be consulted. Mr. J. J. Thomson had proved that an atom did not entirely consist of electrons, but that it consisted of a positive nucleus which was by far the greater part of the mass. The first determination of the number of free electrons in a metal was made by Schuster, and given in the *Philosophical Magazine* in (he thought) March or April, 1904. The Volta series of metals was confined, not only by observations under ultra-violet light, but also, according to Fuchtbauer, under canal rays. The charge of a liquid did not go off with its vapor, the liquid surface behaving in this matter like a perfect semi-permeable membrane.

With the conclusion of the formal debate, which ended after 10 o'clock, your correspondent left the meeting. But an informal debate was waging keenly, "the sea-green unconvertible" (to misquote Carlyle's epithet), Mr. Rhodin urging the view expressed by the great poet that "Knowledge is of things we see," but, unlike the poet, disinclined to accept any views demanding faith.

New Incandescent Lamps.

On Thursday, Jan. 10, a paper on "New Incandescent Lamps" was read before the Institution of Electrical Engineers, by Mr. J. Swinburne (F. R. S.), past president. Of this paper I can only give a brief outline. The author commented on the fact that, since the substitution of a carbon filament for the original expensive platinum, there had been for a long time a period of resignation, and it is only recently that serious efforts have been made to manufacture a lamp having some other material for the filament. The difficulty, of course, was to get a sufficiently high resistance without an inordinate length of wire. The controlling factors were the melting point, the specific resistance, and the possibility of making the filaments in practice.

In the second part of this paper the author reviewed the refractory metals and elements possible in this connection. He considered the processes of manufacture and the limitations these imposed on the materials to be used. Titanium, zirconium and vanadium were among the possibilties. Tantalum, of course, is already in use. Reference was made to its exceptional hardness, a curious property in a ductile material. Osmium and iridium had also been tried practically. Mr. Swinburne was of opinion that the trade would tend towards the manufacture of metal filament lamps. The resulting discussion will be summarized in my next letter, owing to lack of space.

Market Prices

Prices still remain generally high, with the exception of the artificial depression in pig iron, noted below. Copper sulphate is now at £32.10 per ton. Shellac is moderate at 220/ per cwt., and Para rubber steady at 5/2½. Copper is still strong at £107, though slightly easier to £106 about the twentieth, owing to determined selling by important dealers. Platinum is quoted at 150/ per ounce, but it is doubtful if much could be obtained at that price. Tin inclined to rise at £192.10. Zinc is rather easier at £31 15 per ton. Lead is slightly lower at £20.2.6. Cleveland warrants, in the face of a good natural demand, have steadily declined throughout January. This is attributed to the large stock held by dealers. The buyers holding off for further reductions have contributed to bring this about.

A situation of this kind will naturally require delicate handling not to result in a sudden sharp rise in prices. The present price of No. 3 is 57/. Steel rails (heavy) are £6 12 6 net f. o. b., and ship rates £7 10.

London, Feb. 6, 1907.

RECENT METALLURGICAL PATENTS

IRON AND STEEL.

Converter Plant.—The molten pig iron, tapped from the blast furnace, is brought by means of transfer ladles to the steel plant and stored in receivers until it can be treated in the converters or open-hearth furnaces. It is of great importance for continuity of working that the receivers should be always in good order and should be used without opportunity for cleaning or repair for as long periods of time as the steel plant continues in operation. For this purpose it is specially important that such segregations should be avoided in the receivers, as often result from kish and other more or less siliceous substances in the pig iron. Mr. H. H. Campbell, the general manager of the Pennsylvania Steel Co. at Steelton, Pa (843,582, Feb. 12, 1907), has arranged his plant so as to achieve the above object together with saving of time and economy of production in the whole plant. The arrangement is shown in Fig. 1, which is a plan view of a Bessemer steel plant with converters 5 in customary relation to each other, elevated fixed troughs or runners 6 placed behind the converters and under an elevated runway 7 of a traveling crane 8, that carries a charging ladle 9, by means of which molten iron is delivered to the converters. Adjacent this runway 7 are mounted one or more receivers 10, two being shown, and in close proximity to them is the track 11, on which runs the transfer ladle car 12, that moves the molten metal from the blast furnace into the steel plant, the metal being discharged into the receivers by the aid of longitudinally-movable receivers runners 13 properly placed for the purpose. These runners are moved by a hydraulic or air cylinder and piston 14, so that metal can be discharged from the transfer ladle 12 into either one of the receivers without changing the position of the ladle car 12 on its track 11. The cupolas 15 are placed near the receivers and provided with fixed runners 16 uniting at their ends and discharging into a cupola receiver runner 17, that is mounted to be swung out of the way when not required, thereby enabling the contents of the cupolas 15 to be run into the receiver 10. The receivers are so mounted that they can be tipped to pour part of the metal contents into the charging ladle 9 through the pouring spout 21; 33 are the blast mains for supplying air to the Bessemer converters 5. From these blast mains 33 a blast pipe 32 receives a strong blast, and from it branches 34 are provided with valves from which one or more nozzles extend through openings into the receivers, so as to direct the blast above the surface of the metal in the receiver. Mr. Campbell has found that in this way he is enabled to remove accumulations of kish, congealed metal, or skulls, and other accretions incident to receivers, by a process of combustion or decomposition effected by the oxygen of the air burning out the carbon of the kish and melting the slag and other foreign substances, thus keeping the receiver clear of such obstructions for long periods of time and at the same time increasing the heat of the metal contained in the receiver.

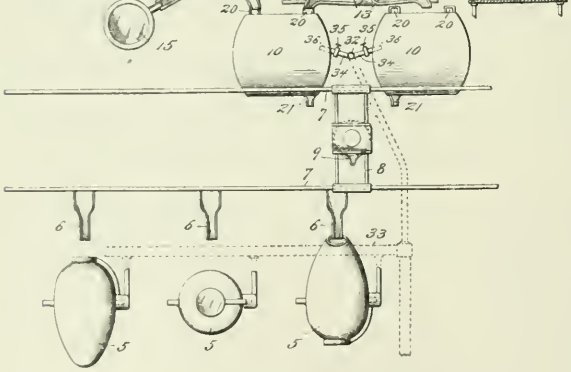


FIG. 1.—ARRANGEMENT OF CONVERTER PLANT.

Making Briquettes.—In the manufacture of cellulose or paper pulp under what is known as the "sulphite process" (which consists in boiling wood and other fibers under pressure in a solution containing sulphurous acid and a base, such as lime or magnesia), a vast quantity of a watery mixture known as "waste sulphite liquor" is produced that so far has had little value. J. S. Robeson (841,718, Jan. 22, 1907) proposes to utilize it for making a binding agent for the production of briquettes from ore fines, etc. This liquor is neutralized by means of milk of lime and then quickly concentrated in vacuo without producing decomposition. To this mass of liquor, with a density of about 30° Baume, the same quantity, by volume, of wood-tar is then added. By the term "wood-tar" is meant the heavy liquid residue from the condensed products of the destructive distillation of woody tissues in the manufacture of pyroligneous acid and methyl alcohol, etc. The combined mixture is heated and is then ready for use as a binding agent for making briquettes of ore, etc. In making the briquettes the required quantity of the binding material will depend entirely on the material. For instance, fuel of a bituminous character will require a smaller proportion of the binder than iron ore. For making iron ore briquettes a mixture of 97.5 per cent iron ore with 2.5 per cent of the binding agent is made. The briquettes after they have left the shaping press are subjected to a temperature not less than 500° F., whereby the briquettes are hardened and at the same time one-half of the sulphur content of the binder is driven off. As a special advantage of the binding material it is stated that the product is absolutely non-hygroscopic.

Converter Process.—In the Bessemer process the object is generally to burn off first silicon and then carbon. On account of the very large oxidation heat of silicon the temperature increases rapidly, and it has been found that if it rises above a certain critical point the oxygen of the blast prefers to burn the carbon rather than the silicon in the steel. Moreover, from the oxidation of silicon no evolution of gas results, except the nitrogen from the air in the blast, and at the high temperature this nitrogen appears to have a deleterious action on the steel (compare, for instance, page 51 of our February issue). Reactions of this sort cause the production of poor steel, often with a high content of silicon. Mr. Byron E. Eldred (843,592, Feb. 12, 1907) endeavors to hold the temperature down below the critical point by not using a pure air blast but mixing the air in the blast with carbon dioxide from the waste gases of some other furnace. By regulating the amount of air and of carbon dioxide the temperature within the converter may be easily regulated. Concerning the effect of carbon dioxide it is said that it is split up, and its constituents enter into other combinations by reactions which are endothermic in character, so as to produce a distinct cooling

effect. The inventor further states. "The carbon dioxide or the products of combustion appear to have a catalytic action, resulting in an acceleration of oxidation of the silicon, carbon, sulphur, etc., and thereby enabling a 'blow' to be made in a much shorter time than that required in ordinary practice. By my process there is from this standpoint, at least, no limit to the rapidity of the blasting, and I am therefore enabled to use converters of larger dimensions than those heretofore employed." As the chief result he states that by his process he is enabled to make in the Bessemer converter steel resembling open-hearth steel, and able to compete with it: this would considerably extend the applicability of the Bessemer process.

Fine Ores.

Treatment of Fine Ores.—A new process of Ferdinand Heberlein (844,355, Feb. 19, 1907) relates to the treatment of fine manganese or iron ore, burned pyrites, blast furnace flue dust and other metalliferous substances in a pulverulent condition. He mixes the fine manganese or other ore with coal and subjects the mixture after ignition to a blast of compressed air. A rapid development of heat takes place, and a sufficiently high temperature is attained to bring about the fusion and agglomeration of the ore under treatment. The volatilizable substances being, moreover, liberated, concentration of the metallic contents takes place. The process may be conveniently carried out in a tip apparatus, such as is generally used in the Huntington-Heberlein process for roasting sulphides. On the perforated iron saucer at the bottom of the receiver is placed a small quantity of live fuel, and upon this is arranged a thin layer of the mixture of ore and fuel. A gentle air blast is then applied, and, as the process proceeds, is gradually increased, the receiver having in the meantime been filled. The combustion propogates itself from the bottom upward, with the result that the substances become agglomerated, there being left in the receiver at the conclusion of the operation a slagged and porous mass ready for tipping and subsequent treatment. When the subsequent treatment is carried out in a blast furnace, the porous condition and lumpy state of the product facilitates the passage of the air blast and other gases and enables regular and economical working to take place. Where the mixture is devoid of moisture it is advantageous to add a certain quantity of water, which not only tends toward the prevention of flue dust formation, but greatly assists in the regular diffusion of the blast throughout the entire mass and in the production of a homogeneous and uniformly well-slagged porous product. As a rule, ores of the character referred to can be treated without the addition of fluxes, but in some instances it is advantageous to add either lime or silica, according to the precise nature of the ore.

Foundry.

Ferro-Silicon in the Foundry.—One of the difficult problems of foundry practice where miscellaneous castings are made is to economically obtain from one melt in a cupola the proper grades of iron suitable for different classes of castings. Thus the articles may range from castings of many tons weight, usually of thick section, requiring strong iron of close-grained texture, often having high chilling properties, to small objects of a pound or so in weight, frequently of thin sections, which may require to be machined, and therefore must be of softer metal having little or no tendency to chill. The practice of foundrymen in the past has been to vary as best as they could the grade of metal in the cupola itself in different periods of heat, and to so group and time their castings as to utilize to the best advantage the different grades of iron obtained from the cupola in one continuous melting operation. In contradistinction to this method Alexander E. Outerbridge, Jr. (842,906, Feb. 5), endeavors to produce the different grades of iron in the metal in the following way. The general run of iron in the cupola is practically not varied by him, iron being molten of a character capable for the castings of the lowest grade to be made, which may have close grained texture and high chilling properties. He then taps into a ladle a charge sufficient for a particular casting or group of castings which it is desired to make of softer iron having but little chilling tendency. With the molten metal in the ladle he now combines a definite amount of powdered ferro-silicon (containing 50 per cent of silicon). Hard iron can be modified so as to produce a relatively soft gray iron by the addition of even so little as 1 pound of 50 per cent ferro-silicon to 200 pounds of iron. Within certain limits the desired physical characteristics of the metal can be accurately controlled in correspondence with the percentage of the ferro-silicon thus added. The novel feature of the process is claimed to be that the ferro silicon is added to the contents of the ladle and not to the cupola.

Zinc.

Distillation Furnace. A. Desgraz and P. Schmidt (843,872, Feb. 12, 1907) point out that to recover as much zinc as possible from the ore in the distillation furnace, the temperature should not at first be allowed to rise too rapidly since otherwise a serious loss would ensue through the escape of uncondensed zinc fumes from the condensers. As the distillation progresses the temperature is gradually increased, and just before the end of the process it is rapidly raised to white heat, and then, upon the emptying of the separate muffles, again almost immediately reduced to the initial temperature. During all stages of the operation the temperature should be absolutely uniform throughout the whole furnace. The inventors try to accomplish this end by the use of a furnace with a free flame space with rows of muffles on both sides, in the floor of the combustion chamber several pairs of burners are arranged, each of which is connected with the gas supply pipe by means of a regulating valve to be acted on from outside, while the air introduced in a common heating channel is fed to the pairs of burners by means of openings, the opening of each pair of burners being adjustable from outside. By this means there is obtained throughout the furnace a uniform temperature, which can be regulated in accordance with the requirements of the process.

Precious Metals.

Roasting Furnace.—There are certain ores carrying precious metals in such combinations that when the ore is roasted a considerable percentage of the gold and silver volatilizes in the form of fumes. To prevent this loss, John E. Greenawalt (839,064 and 839,065, Dec. 18, 1906) uses a longitudinal roasting chamber (with rabbling mechanisms, etc.) with a porous bed on which the ore is roasted. Producer gas for furnishing the heat for roasting is supplied to the roasting chamber at one point while at further points air is introduced at intervals into the chamber. The mixture of air and gas is passed downwards through the roasted material and through the porous bed forming the support for the material by means of suction acting from below. A condensing chamber is provided below the porous hearth, and so it the fumes are condensed. Not only the precious metal values contained in the fumes are recovered, but it is possible to treat the sulphurous fumes for the manufacture of sulphuric acid. The inventor states that "by incorporating a suitable catalytic agent—such as platinized asbestos, ferric oxide, etc.—in the porous bed a considerable proportion of the sulphurous anhydride can be cheaply and economically converted into sulphuric anhydride and thus into sulphuric acid in the condensing chamber."

Chlorination.—Another patent of Mr John E. Greenawalt (837,560, Dec. 4, 1906) relates to improvements in apparatus for chloridizing ores. Its object is the treatment of ores, when in a heated condition, by use of chlorine gas in such a manner as to prevent a loss resulting from the volatilization of the metallic values. When an ore is roasted with salt the first chlorine released acts upon the base elements in the ore, and it is only after free chlorine is released from the ore that the

...ls volatilize to any great extent. In carrying out the invention the inventor adds a small amount of salt, generally from 0.5 to 1 per cent to the ore. The construction of his

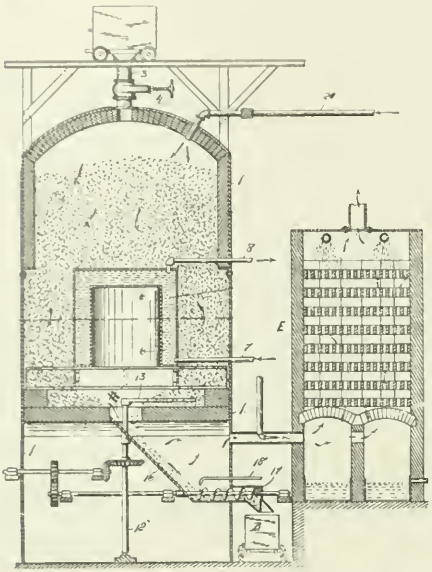


FIG. 2.—CHLORINATION PLANT.

apparatus is shown in Fig. 2. The chloridizing tank consists of an outer shell 1 of sheet steel. The hot ore is brought to the roasting furnace by a car and is discharged into the top of the chloridizing tank through the pipe 3. The chlorine is introduced through the pipe 20. When the valve 4 in the pipe 3 is closed, the entire upper portion of the tank is gas tight, and a pressure of a few pounds is sufficient under most conditions to cause the gas to permeate the entire ore and percolate downwardly through the ore in the chloridizing chamber. The chlorine gas reacts with a hot ore. But before the inert gases that may be mixed with the chlorine or the surplus can escape from the tank they must percolate through the cooling zone in the lower portion of the tank. The cooling effect is produced by the means of the water-cooled shell 6, cold water entering through 7 and the heated water, together with steam, leaving through 8. In this way the temperature of the volatilized fumes is reduced sufficiently to cause precipitation to a considerable extent. By means of the arm 13 revolving around the shaft 12 the chloridized ore is stirred and discharged into the chute 16, from where it is passed into the screw conveyor 17, in which the ore is moistened with water supplied through the pipe 18, and discharged into the cart B. The gases and steam escaping from the chloridizing chamber are passed into the condensing chamber E, where the remaining values contained in the gases are completely precipitated.

ROASTING FURNACE.

Cooling Devices.—To the long list of patents granted to Mr. Frank Klepetko on details of construction of the McDougall roasting furnace another one has recently been added, its number being 843,825, of Feb. 12, 1907. It refers to the water-cooling devices. Claim 2, which indicates the general character of the construction, reads as follows: "In a furnace having a plurality of hearths, a rotable hollow shaft passing through the hearths, a series of hollow arms radiating from said shaft and extending into the several hearths, a series of chambers distributed throughout the shaft and communicating with the hollow arms, and a water-feed pipe extending through the several chambers and discharging its water into the same."

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

ELECTROCHEMISTRY.

Calcium Cyanamide.—The ordinary method of making calcium cyanamide consists in heating finely-ground calcium carbide in an atmosphere of nitrogen. The product contains about 20 per cent of nitrogen, but should be theoretically higher, and apparently only about 70 per cent of the carbide is changed into cyanamide. Since for this reaction a high temperature is required, it is difficult to get an air-tight furnace, as the walls become permeable for gases and oxygen of the air diffuses into the furnace and oxidizes an appreciable amount of the calcium cyanamide, according to the equation $CaCN_2 + O_2 = CaO + CO + N_2$. In an article in *Chemiker Zeit.* of Dec. 19. Fredrik Carlson considers this to be the cause of the low efficiency of the old process. He mentions, as other disadvantages high cost of repairs, etc. Polzenius (German patent 163,320) has later devised another process in which the carbide is mixed with 23 per cent of calcium chloride. The advantage is a much lower temperature and almost theoretical efficiency. But the cyanamide produced in this way has certain bad properties, since on account of the addition of calcium chloride the product becomes hygroscopic and the bags in which it is shipped rip. Moreover, nitrogen is lost probably in form of ammonia. For this reason analysis often shows less than 20 per cent nitrogen. The present author, on the suggestion of his father, has tried whether instead of calcium chloride calcium fluoride could be added, fluorspar being cheap and abundant. The results of tests made in Prof Foerster's laboratory in Dresden were very good, the efficiency being high and the temperature of reaction much less than without the addition. Further, the disadvantages of the cyanamide produced by the Polzenius' method are here entirely absent.

Distillation of Alloys.—Last year, H. Moissan gave an account of extended experiments in which he evaporated in an electric furnace a great many different metals, and after distillation deposited the metallic vapor on a cold mirror. Together with T. Watanabe (*L'Industrie Electrique*, Jan. 25) he has now studied the evaporation of alloys in the electric furnace. If an alloy containing originally equal quantities of silver and copper is evaporated, silver evaporates principally, and the residue will contain almost nothing but copper at the end of 15 minutes after beginning evaporation. If an alloy of silver and tin is treated the same way the silver is evaporated; with an alloy of silver and lead the lead is evaporated.

IRON AND STEEL.

Melting Cast Iron.—Eug. Geilenkirchen, of Hürde, discussed in *Stahl und Eisen* for Jan. 2 and 9, in a paper read before the Vereins deutscher Eisenhüttenleute, the use of the

reverberatory furnace in foundries instead of cupolas, particularly in malleable iron works. The cupola will melt pig iron with 10 per cent of its weight of coke, while the reverberatory (sometimes called "air" furnace in America) requires 30 per cent of its weight of soft coal. Since coal is only about two-thirds the price of coke, the 30 per cent costs as much as 20 per cent of coke, making the fuel cost double. For ordinary castings the advantages are all on the side of the cupola, but for high quality castings the conditions are different. The reverberatory permits the close regulation of the composition of the iron, especially as to low carbon and sulphur, the holding of the charge until its composition is known to be right, the furnishing of a large amount of melted metal at one time of uniform composition, and the possibility of melting down of large unbreakable castings. The Siemens regenerative gas furnace is a fine furnace for the iron foundry, although at present used mainly for melting steel. With it any grade of cast iron can be furnished. A very simple form, of only 2 tons capacity, was built for the writer by Heinrich Eckardt, in Berlin, which with generators included cost only 18,000 marks. Acid lining is better for foundry purposes than basic. Such furnaces, if properly built and handled, will furnish two to three charges a day for a year without shutting down for repairs. Such small furnaces will consume, however, 45 to 50 per cent of fuel on the weight of charge melted. Part of this high fuel consumption is due to working only by day; the furnace might be profitably worked at nights also, on melting less particular material, with less attention. The composition found best for castings to be malleableized is: carbon under 3 per cent, silicon 0.4 to 0.8, manganese not over 0.4, phosphorus not over 0.2 at most and if possible under 0.1, sulphur not over 0.1 and it possible under 0.05 per cent.

Determination of Iron.—In the *Mining and Scientific Press* of Dec. 15, 1906, Mr. E. B. Van Arsdale recommends a scheme with which he has had satisfactory experience, and the purpose of which is to perform the reduction of the iron immediately previous to titration, in order to limit the source of error which might be introduced on account of the oxidation of the solution after reduction and before titration. He proceeds by dissolving the precipitated ferric hydrate in one to three hydrochloric acid, and adds 3 or 4 grams of potassium iodide crystals and titrates immediately with sodium thiosulphate solution, using starch indicator. The reaction is then as follows: $Fe_2Cl_6 + 2KI = 2FeCl_2 + 2KCl + I_2$ in the presence of HCl. The free iodine dissolved in potassium iodide is titrated by the thiosulphate according to the usual reaction. The author has found the reaction to be complete in the cold and instantaneous, provided sufficient hydrochloric acid is present. The author states that the starch iodine color will return very soon after the titration is finished, and is due to reoxidation of the iron by the air and the subsequent liberation of iodine. This must be disregarded. The solution from which the iron was precipitated as hydrate must have been sufficiently oxidized by nitric acid, potassium chlorate, bromine water or similar substances in order to ensure complete precipitation. Arsenic, antimony and tin must be eliminated, which can be done easily by a previous precipitation of the iron by ammonium sulphide. Lead will usually have been removed by precipitation, as sulphate and bismuth occurs so rarely that no notice is taken of it in the present instance. The standard of thiosulphate for iron will be to the copper standard as their atomic weights, that is, 56 to 63, as either of them liberates two atoms of iodine.

Literature.—The increased amount of information being published regarding iron and steel is evidenced by the enlargement of our esteemed contemporary *Stahl und Eisen*, the organ of the Verein Deutscher Eisenhüttenleute, from a semi-monthly to a weekly. With its forty pages of reading matter and seventy odd pages of advertisements, weekly, it is a splendid proof of the permanency of the advance of iron and steel.

Meeting of the Verein Deutscher Eisenhüttenleute.—*Stahl und Eisen* for January contains the proceedings of the meeting of this society at Dusseldorf in December last. Nearly 1,400 members attended the meeting, and 700 sat down to the *Festmahl* in the Kaisersaal. The joviality of the banquet is attested to by the numerous punctuations of the proceedings by happy speeches received with *"Bravo," "Grosse Heiterkeit," "Stürmische Zustimmung," "Allseitiger, lebhafter, langanhaltender Beifall,"* etc., etc., and ending with the singing of an original poem in honor of Dr. Schrödter and *Stahl und Eisen*. A pleasant feature was the presentation of the Lueg memorial medal to Dr. Schrodter, in commemoration of his twenty-five years service to the society as its secretary and editor of its organ—*Stahl und Eisen*.

Gold and Silver.

Milling Practice with the Lane Mill.—An interesting comparative experiment, in order to try the improvement in the results by introducing a slow-speed grinding mill of the Lane type as an auxiliary to the batteries, is described by Mr. J. A. Stewart in a communication to the *Mining and Scientific Press*, Feb. 2, 1907. The mill consisted of two five-stamp units and treated ore from a rich shoot in the Eureka mine, Whatcom County, Wash. One of the five-stamp batteries was supmented by the installation of a slow-speed Lane mill, which was to do the fine crushing, the stamps being only used as a secondary crusher. The other five stamps were run the regular way. The Lane mill was 10 feet in diameter, and was placed in front of the battery, which consisted of five 1,000-pound stamps. The intake of the mill was made low enough so that the pulp from the battery could be delivered to it by gravity. The battery was provided with a ¼-inch mesh No. 16 wire screen, and the stamps were dropped 6 inches with a 4½-inch discharge. The Lane mill was fitted with an 8-mesh wire screen and 6-inch discharge, and the pulp discharged onto plates 5 feet wide and 18 feet long, after which it was sent to two Wilfleys. The other battery of five 1,000-pound stamps, dropped 6 inches with a 5-inch discharge through a 25-mesh wire screen, and the pulp was run over plates 5 feet wide by 20 feet long, and then over one Wilfley. The following saving was shown:

Stamp System.	*From Foot of Plates.*	*Lane System.*
51%		65%
	From the Wilfley Tables.	
80		91
	Screen Test of Tailing	
90% passed	30-mesh.	90
70 "	40 "	88
42 "	60 "	60
36 "	80 "	50
14 "	100 "	36
	Screen Test of Concentrate.	
97% passed	30-mesh.	99
89 "	40 "	96
58 "	60 "	92
51 "	80 "	88
20 "	100 "	80

Mr. Stewart remarks that the product from the stamps when examined by the magnifying glass shows sharp edges and angular shapes, while the reground product has rounded edges and is of globular form. Thus the regrinding process in the Lane mill produces a product which is entirely different from that of the stamps, and in his judgment better for amalgamation. The Lane mill was run at 6 revolutions per minute, and crushed 40 tons per day of 24 hours, whereas the stamps crushed 10 tons with the 25-mesh screen, dropping ninety six times per minute. The horse-power required for the Lane mill with full load is 12 hp. The author estimates that the cost of repairs will not exceed 3 cents per ton of ore crushed, while the hardness of the ore under treatment is

above the average. By increasing the speed of the mill from 6 to 8 revolutions per minute, he expects a crushing capacity of the mill of at least 50 tons per day.

Filter Practice in Cyanidation.—Commenting upon the article by Mr E. H. Nutter, mentioned previously in the Synopsis, which dealt with the advantages of the Moore method of filtration, Mr. F. L. Bosqui, *Mining and Scientific Press*, Feb. 2, 1907, calls attention to the advantages of the stationary filter used in the Butters-Cassel process. He thinks that this feature constitutes one of the chief points of merit in the Butters-Cassel process. In order to ensure good work, that is, a uniform deposition and a clear filtrate, the frame must be as nearly as possible straight and true and the canvass must be free from weak places, ripped seams, etc. In the interval between complete deposition and the displacing operation, there is a period of suspension, during which the vacuum is reduced just enough to hold the cake in loose adherence to the canvass, but not enough to dry and crack the cake. Thus, the maintenance of the slime cake in the best condition for displacement by water is a delicate operation which requires careful manipulation. In order to give the best results the filter must not be stretched or strained. The author maintains that it is practically impossible to transfer the filter frames in the Moore process without straining to a greater or less degree the frame and disturb the integrity of the cake. The seams of the canvass are subjected to an alternating tension and relaxation, and they therefore weaken and finally give way, causing leaks and murky filtration. This straining action, therefore, not only interferes in various ways with perfect filtration, but also makes necessary many repairs to the frames. Mr. Bosqui states that the Combination plant at Goldfield, where the Butters-Cassel process is in operation, has run with uninterrupted smoothness from the day of its installation, and the filters have never been taken out for repairs during a service of nearly one year.

Method for Obtaining the Density of Settled Sand.—Various methods are in use for calculating the tonnage of sands contained in settling tanks, but they are liable to inaccuracies of greater or less extent. The following procedure is followed in the plant of the New Goch Gold Mining Co. in the Transvaal, and works satisfactorily according to Mr. D. Simpson, who described it in a recent brief paper before the Chemical, Metallurgical and Mining Society of South Africa. (*Journal Chemical, Metallurgical and Mining Society of South Africa*, August, 1906).) The weight of a known volume of sand is taken by means of a rectangular prism made of stiff sheet iron. Its size is 7½ inches square by 9 inches deep, with a slot the whole width of three of the sides 7½ inches from the top, giving an effective cutical content of about 422 cubic inches. In order to calibrate the instrument it is placed inverted on a sheet of soft rubber and kept in position by means of a bar passed into the slot, the bar being sufficiently curved near the middle so as not to interfere with the surface of the water, which is filled into the box from a graduated vessel up to the slot. The error, due to the rise in level of the rubber surface inside of the prism, has been found to be compensated for by the curved surface of the water above the dry edge of the slot. The apparatus is used as follows: A mass of sand at the desired level is blocked out with set-square, foot-rule and trowel in situ in the tank during its discharge, care being taken that the surface is not trampled upon. Its size is gradually reduced until its sides are about ¼ inch longer than the sides of the above-mentioned prism and are at right angles to one another. The prism is then very carefully and gently lowered on to this mass, perpendicularly to its full depth, the small excess of sand at the sides being thus cut off. A thin plate of steel, say, 9 inches wide and 1 foot long, with a knife edge, fitting firmly into the slot, is then gently pressed into the slot until its forward edge rests against the fourth side of the prism. The exposed upper surface is then leveled off with a flat steel bar. If these operations are conducted with the necessary care, compression of the pulp is said to be entirely obviated. The sample is then lifted bodily in the prism, put into a pen, weighed and dried and from it and from similar samples taken at various positions in the tank the tonnage is calculated as usual. The author has found this the most reliable method he has investigated.

Cyanide Practice on Boulder County (Col.) Ores.—In a paper read before the annual meeting, December, 1906, of the Western Association of Technical Chemists and Metallurgists, Mr. F. Leonard describes the practice at the Cash mill, Magnolia, Col. adopted in the treatment of a telluride gold ore. The ore averages about $15 of gold per ton. It is crushed in a Dodge crusher and rolls, the product delivered to the finished ore bins being of 6-mesh size. It is then roasted in a cast iron rotary dryer, lined with firebrick, the fuel being crude oil from the Boulder field. The oil is applied with a burner that can be adjusted for the purpose of regulating the blast and controlling the combustion. The ore is introduced by means of an automatic plunger feeder, through a curved 3-inch pipe, the ore being deposited 1 foot from the upper end of the cylinder, which is 16 feet long. The inclination in the whole length of the machine is 10 inches. The ore is passed through continuously, a charge requiring 18 minutes to pass through; it is discharged upon a cooling floor. During this roast the sulphur is reduced from 5 to 8 per cent to five-tenths of 1 per cent. The capacity of the roaster is dependent slightly upon the character of the ore, but it usually is 10½ tons per shift of 8 hours, with a consumption of 7 to 8 barrels of crude oil. The roasted ore is spread in thin layers as it is discharged and is allowed to cool. The gold is perfectly free and bright, considerable coarse gold shows when high-grade ore is being treated. An amalgamation process is in course of construction. The cyanide mill is provided with four 15-ton and two 30-ton leaching vats. The vats are charged with hand barrows, and as there often is a quantity of charcoal in the ore, owing to chips from timbers in the mine, the ore is dumped first into about a foot of cyanide solution, say, of .03 per cent strength; this serves the double purpose of acting as a preliminary wash and of floating the carbon, which latter is skimmed off. The solution is drawn off, and in order to complete the washing and to further eliminate the soluble iron salts, due to the roasting, the regular stock solution is run on, covering the charge. This is then drawn off into the weak solution sump until the cyanide strength shows one-half that of the standard solution, which latter stands at 0.5 per cent, or 10 pounds to the ton. It is then run into the standard sump until a strength of 8 pounds per ton is reached, and then it may safely be run through the zinc, as by this time it is very clear and pure. In a 30-ton vat about 8 tons of weak solution are required. When this is drawn off, 7 to 8 tons of the standard solution are required to cover the charge and as much more will be run on before the changes take place, which bring it up to the strength required for entering the boxes. The rate of flow is regulated as circumstances require. In order to avoid contamination of any considerable quantity of the stock solution with the sulphates so abundantly in circulation, the strong solution is pumped from its sump and distributed over the vats that have already started to leach. Just as the solution is ready to be directed through the zinc, the solution in the strong sump is standardized, pumped up and returned to the vat of ore it just passed through, where the sulphates are nicely filtered out and the solution goes through clean. The sulphates are skimmed off. Leaching goes on in the usual way until intermediate sampling shows a satisfactory extraction. The cyanide consumption takes place mostly during the first wash with weak solution, the actual consumption being about 2 pounds per ton of ore treated. The tellurium in the ore does not seem to require any further attention than the roasting process described above, and the author

is led to believe that under certain conditions the slightest roast will suffice.

Tube-Mill Lining.—The question of tube-mill lining has been repatedly touched upon in these columns, as it is of considerable importance. Records of life have been given from various sources, and the best practice is gradually being evolved. Another record of experiments carried on with various linings at the stamp mill of the Standard Consolidated Co., at Bodie, Cal., is given by Mr. W. W. Bradley in *Mining and Scientific Press*, Jan. 5, 1907. The tailing flow from the mill passes through classifiers and the tube mill regrinds the underflow from the latter, and it is also fed with dry tailings from the old slime ponds. The tube mill of the Allis-Chalmers type is about 22 feet long by 5 feet in diameter. The first lining of the mill was made up of special steel plates of about 10 x 12-inch area by 1 inch thick, the base being made in such a manner that the entire lining was interlocking. The plates lasted 4 to 5 months, but some of them would wear unevenly and occasionally one would drop out, which necessitated the stoppage of the mill and the replacement of the loosened plates. The next lining tried was composed of blocks of pine cut from 4 x 6-inch timber into 6-inch lengths. The blocks were slightly wedge-shaped in order to allow for the curvature of the mill, and were set on end. About 36 hours were required to place a new set of these liners, including removal of the old blocks and shoveling the load of pebbles out and in. A set of these liners lasted from ten days to two weeks, and the wooden blocks had the additional disadvantage of producing a soapy mixture with the alkalies present in the cyanide solution. And this saponification was the cause of excessive foaming in the batteries and on the plates of the mill, as well as in the tube mill, the launders and the vats of the cyanide plant. A set of liners made from mountain mahogany lasted a few days longer and the saponification was decreased. After this experiments were made with a quartz lining, which consisted of selected pieces of chalcedonic vein stuff, from the mine, which was very hard and close-grained. The lining was carefully laid with Portland cement and allowed to set for about ten days. In less than one-half hour after starting up the pounding of the pebbles caused the lining to break. The next lining experimented with was of silex, but this did not have as long a life as was expected on account of the uneven wear and the occasional dropping out of blocks. The lining which was then put in was made up of wrought iron bars, 8 inches wide by 1 inch thick, cut in 15 and 7-foot lengths. The length of 15 feet was the longest that could be handled through the man hole of the tube mill. The bars were put in alternating in order to break the joints lengthwise of the tube mill, and were bolted with countersunk bolts passing through the shell. The liners were all drilled to the same measurements for the bolt-hole, and when the first set was put in, holes were drilled in the tube-mill shell to correspond, so that no further drilling of the shell was required for any subsequent sets. The experience with these liners has been very satisfactory, as they give a life of between three and four months, and are easy to change. The entire operation of shoveling in the load of pebbles, unbolting the old and bolting in the new liners requires only between 20 and 24 hours. The width of the bars, which is 8 inches, as mentioned above, is such that they do not fit closely to the cover of the shell, and on account of this the pebbles have a tendency to turn over on themselves instead of sliding, and this is an advantage, as the sliding action wears out the lining rapidly. The mill with this lining has been grinding from 50 to 75 tons per day. The portion of the stamp mill product which requires regrinding is principally composed of a tough, hard chalcedonic quartz.

Copper.

Over-Fire in Copper Matting Blast Furnace Practice.—In observing the running of copper smelting furnaces it is frequently noticeable that there is quite a difference in their behavior from that of lead smelting furnaces, as the latter usually run much more quietly than the former. Frequently in copper blast furnaces there is a good deal of over-fire, and the escaping gases are often highly heated. Mr. L. S. Austin, in *Mining and Scientific Press* of Jan. 5, calls attention to the fact that though this condition of affairs seems to be the usual in copper smelting furnaces, it is not necessarily so. If a silver-lead furnace were to be run in this way a great deal of the lead in the charge would be volatilized and would pass off with the escaping gases. With copper, however, the loss is not very great, though sometimes the blue color of the rising flame gives indication that some such loss actually takes place. However, apart from this, the author is of the opinion that much heat escapes uselessly which should be utilized at the tuyeres, where it is needed to keep the tuyere zone hot. In order to keep down the over-fire as much as possible, the feeding and operation should be attended to properly and the fuel should be also diminished, while the blast should be heated at the same time. In regard to the first desideratum, that is, the proper feeding and operation of the furnace, in the opinion of the author, much more can be done than is generally accomplished by packing the charge, keeping the shaft clear and free from accumulations, feeding large charges properly segregated, keeping the tuyeres open, and feeding fuel so as to come down in front of them. With regard to the heating of the blast, it has been found that hot or even warm blast greatly assists in increasing the heat at the tuyere zone and thus brings the furnace into the best condition. The author states that he has seen copper matting furnaces, and especially those that were devoted to the smelting of roasted leady copper matte, run with but little over-fire, and certainly without the excessive heat which can be observed in the operation of many ordinary copper furnaces. On this account he believes that these conditions need not necessarily exist, and that they can be improved to a greater or less degree.

Alloys.

Alloys with Manganese.—S. Wolgodine, in *Revue de Metallurgie* for January, gives the results of systematic examinations of these alloys made in Le Chatelier's laboratory. The fusibility was found as follows:

Percent. Manganese.	*Melting Point.*	*C°.*
0	1,085	....
5	1,050	....
10	1.000	....
15	950	....
20	915	....
25	890	....
30	880	....
40	850	....
50	860	895
60	860	1,000
70	865	1,100
80	....	1,140
90	....	1,010
95	....	1,140
100	....	1,275

The study of these figures shows two eutectics, at 40 per cent and 90 per cent manganese, and the existence of the single compound Mn^4Cu, at 78 per cent manganese. This compound is also characterized by much greater hardness than any other of these alloys.

Properties of Alloys of Aluminium and Copper.—A large number of tests has been made by H. C. H. Carpenter and C. A. Edwards to ascertain the properties of alloys of aluminium and copper, and the results of their work are embodied in a report to the alloys research committee of the British Institution of Mechanical Engineers. The report is abstracted in the *Iron and Coal Trades Review*, London, Jan. 25. In regard to the preparation of the alloys the authors arrived at the following conclusions: 1. There is no need to melt the alloys rich in

copper in order to obtain thorough mixing, obviate brittleness and secure the best mechanical properties. With due care the first cast is as likely to be as good as any that may follow it. Such differences in properties as have been found are probably to be ascribed to accidental variations in the conditions of preparation, of which probably the most important are variations in the casting temperature and small holes in the castings. This remark, however, does not apply to large castings, in the case of which remelting may always constitute the best practical method of insuring homogeneity. 2. Copper-rich alloys can be perfectly satisfactorily prepared from the pure metals, and no advantage is gained by using the 50 per cent alloy instead of aluminium. The authors have prepared alloys either from the pure metals or from copper and the 50 per cent alloy, and the continuity of properties which has been found in the various members of a series constitutes additional evidence that the alloys may be satisfactorily prepared by either method. 3. Alloys rich in aluminium can also be satisfactorily made with only one melting. This remark applies likewise only to small castings, and the authors have found that it is far more important, in order to get the best mechanical properties, to cast these alloys at the right temperature, than to remelt. The authors have ascertained that the limit of industrially serviceable alloys must be placed at 11 per cent of aluminium, and this limit for most industrial purposes might be put at 10 per cent, as beyond this occurs a rapid fall in ductility with no rise of ultimate stress. Between these limits the alloys fall into two classes, namely: 1, those containing from 0 to 7.35 per cent of aluminium, and 2, those containing from 8 to 11 per cent of aluminium. In the first class the material is of apparently low-yield point and moderate ultimate stress, but of very good ductility. The introduction of aluminium causes a gradual increase of strength but hardly affects the ductility. The material is not very sensitive to heat treatment, but is much improved by mechanical work. The second class comprises alloys of relatively low-yield point but good ultimate stress, and from 8 to 10 per cent of aluminium the ductility is also good. Certain alloys in this class are very sensitive to heat treatment. The classification of the alloys into these two chief classes, as regards mechanical tests, was confirmed by microscopical examination. Up to 7.35 per cent of aluminium the alloys consisted of ductile crystals of a solid solution. Heat treatment affects the size of the crystals to some extent, but does not cause profound structural changes as is the case with alloys containing from 9 to 11 per cent of aluminium, its influence on mechanical properties being not far reaching. However, the crystals are much broken up by rolling, and are interlocked into a tougher combination than the cast material. The sudden stiffening of the alloys beyond 8 per cent of aluminium coincides with the appearance of a dark structural constituent, which was found acicular. Brittleness is usually associated with such a structure, the alloy containing 11.73 per cent of alluminium, where the structure is wholly acicular, is only slightly ductile. A further important result of the investigation concerns the corrosion of the alloys in sea and fresh water. The conditions of the tests were made as severe as possible, and the alloys containing from 1 to 10 per cent were found to be practically incorrodible by sea water, whether alone or bolted to a plate of mild steel. The authors, however, call attention to the fact that this result does not necessarily hold true in cases where sea water is exposed to local contamination of particular kinds, for example, town drainage, etc. In the sea water tests the alloys were found to be undoubtedly superior to both Muntz metal and Naval brass, both of which alloys corroded appreciably. The fresh water tests, however, gave an opposite result, as Muntz metal and Naval brass plates were unaffected, while the copper aluminium alloys corroded to some extent. In this investigation cast plates of the aluminium copper alloys and rolled plates of Muntz metal and Naval brass were used. The authors believe that cast specimens are usually more readily attacked by liquids than rolled specimens, and, if this is so, then the conditions of test were severer for the copper aluminium alloys than for the other two. The rich aluminium alloys appear unaffected by such heat treatment as quick or slow cooling. Small chill castings possess superior mechanical properties to sound castings. In order to get the full value of the inherent properties of the alloys, a considerable amount of mechanical work; *i. e.*, rolling or drawing, with or without annealing, should be performed upon them. From 0 to 8 per cent of copper all the alloys roll well, and from 0 to about 4 per cent of copper they draw sound. The tests of sand and chill castings and of the rolled and drawn bars agree in showing that nothing is to be gained by adding more than 4 per cent of copper to aluminium, the introduction of copper causing a fall of ductility and a rise tenacity, which are fairly steady up to 4 per cent. Beyond this there is no increase in tenacity while the ductility continues to diminish. The elastic ratios of the rich aluminium alloys average much higher than those of the rich copper alloys. The variation of properties, caused by the introduction of copper, have been shown in the case of alloys in the form of sheets to be similar to those in the form of rolled and drawn bars, particularly in so far as nothing is gained by adding more than 4 per cent of copper. As far as corrosion is concerned, the rich aluminium alloys showed a behavior exactly opposite to that of the rich copper alloys, inasmuch as they were strongly corroded by sea water but uncorroded by fresh water.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Calcium Carbide.—H. L. Hartenstein, 844,018, Feb. 12, 1907. Application filed April 17, 1905.

The object is to make a high-grade calcium carbide from a cheap raw material, found in many places in the United States and elsewhere, and known as "marl." It occurs in the form of a pulverulent lightly coherent earth or mud, and is ordinarily found in beds in swampy places and comprises about 20 to 50 per cent of water. In this condition it is grayish or grayish-white; when dried it becomes much lighter in color. In spite of the fact that marl is widely distributed and easily obtained its use has hitherto been restricted to the manufacture of Portland cement. The native marl ordinarily contains from 95 to 98 per cent pure calcium carbonate, and on account of this fact the material may be used for the manufacture of calcium carbide. The marl is first dried to a certain extent, thoroughly crushed or powdered and then calcined in a suitable rotary calcining furnace at a temperature of about 3,000° F. A certain amount of moisture in the marl is here advantageous since it serves to hold the particles of marl together and prevents them from being blown out of the calcining furnace in the form of dust. Further, the presence of moisture accelerates the expulsion of the carbonic acid from the marl. The moisture is converted into steam, and a current of steam and hot air disintegrates and reduces the calcium carbonate much more quickly (under proper conditions in one-eighth the time) than a current of dry air alone would be able to do. The calcined material consists largely of pure oxide of lime with a small percentage of silica, magnesia and alumina. This hot mass is then mixed with a measured quan-

tity of coke, which has been preheated by the waste gases from the calcining furnace, and the hot mixture is introduced directly into the electric furnace where the calcium carbide is produced. The advantages claimed are that a superior grade of calcium carbide is produced from an inexpensive material; that the expense of disintegration is very much reduced; that all handling and carrying of the material during the various stages of the process is avoided; that the process is made exceedingly rapid, and that care is taken to utilize as much as possible of the heat produced in the calcining stage, so as to reduce the expenditure of electrical energy for the electric furnace operation as much as possible.

Electric Zinc Furnace.—Edward R. Taylor, 843,776 and 843,777. Feb. 12. Application filed May 15 and 27, 1902.

The design of the furnace which serves for the distillation of zinc and other volatile products is shown in Fig. 1 in vertical and horizontal cross-section. The zinc ore, mixed with carbon, and if desired with a suitable flux, is introduced into the furnace through charging openings 22 at the top, and passes downward around the hood 10 to the lower portion of the furnace. Finely divided retort carbon or coke is introduced into the charging tubes 9, and graviates over and between the four electrodes 4, filling the space between the retaining walls 7 and also falling between the working faces of the electrodes 4, and there forming a granular bed in which the necessary temperature is developed. This granular bed of carbon between the electrodes constitutes the reaction zone of the furnace. (The graphite electrodes 4 are connected with the outside by means of the metallic conductors 5 and 6. The electrodes are protected on each side by the retaining walls 7.) The hot granular bed of carbon between the electrodes constitutes the reaction zone of the furnace. The ore adjacent is brought to a temperature sufficient to determine its reduction, and by rotation of the screws 23 and 24 (which are preferably provided in two rows one above the other) fresh quantities of the charge are fed thoroughly into, around and upon the reaction zone, there to be reduced in turn. This feeding may be aided when necessary by stoking. Any slag and non-volatile reduction products collecting beneath the electrodes may be drawn off through tap holes 27 and 28. The gaseous products of reaction, including the gases developed by the reduction of the zinc or other volatile element of the ore, pass upward toward the interior of the bell or hood, and may leave the furnace by either of the following two ways either through tubes 17 and 18 (which are rectangular to each other), and discharge into the condenser 15, which is connected with the outside through the tube 29, or they may pass upwards into the hood and discharge through the tube 14. By partially closing valves the gases can be forced either into one or the other way. The heavier constituents as the zinc will tend to pass through the conduits 17 and 18, in which the condenser 15, while the fixed gases or a portion of them escape through the outlet 14. From the condenser 15 the pipe 29 extends outward and upward, and serves to conduct from the chamber any uncondensed vapors. The principal object of this design is to obviate as much as possible loss of heat by radiation from the furnace walls and to prevent the corrosive action of the products upon the fixed elements of the furnace. Patent 843,776 refers to the furnace, 843,777 to the process.

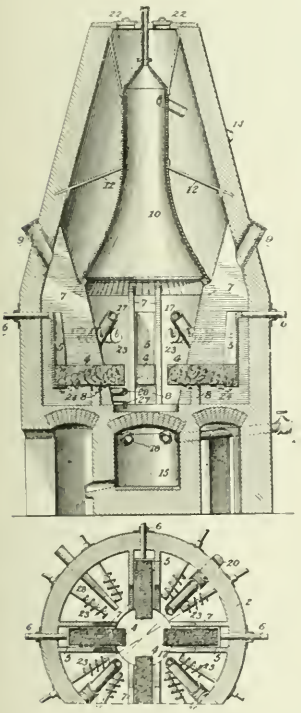


FIG. 1—ZINC FURNACE.

Electrolytic Processes.

Electrolytic Refining of Metals.—A. Schwarz, 842,254, Jan. 29. Application filed Feb. 6, 1904.

The object is to electrolytically refine metallic concentrates without any previous smelting of the concentrates into matte. The concentrates are compressed by any suitable means into solid masses or cakes of a form or size, so as to be inserted in a suitable framework somewhat after the manner of the plates for storage batteries. The framework may be of wood and covered with a conducting material. As an example the treatment of chalcopyrite ore is given. The ore is crushed and concentrated, and the concentrates are compressed into a frame as described and used as anodes in the electrolytic tank containing copper sulphate with an excess of sulphuric acid. The copper is then deposited on cathodes with a current density of 3 to 5 amps. per square foot. The iron contained in the concentration goes into solution in the form of a sulphate, and after all the copper has been dissolved and deposited the solution is treated for the separation and recovery of the iron in the form of an oxide and the sulphuric acid. The slimes are treated for the recovery of any gold, silver, antimony, etc.

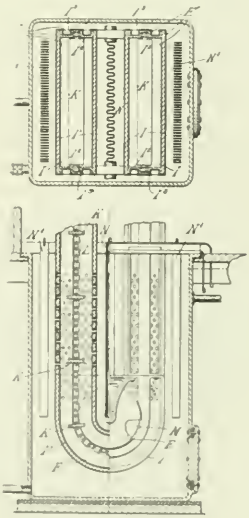


FIG. 2.—DETINNING APPARATUS.

Electrolytic Detinning.—Meredith Leitch, 843,616, Feb. 12, 1907. Application filed July 5, 1906, assigned to American Can Co.

The tin scrap which forms the anode is placed within a perforated iron basket, the outside of which as well as portions of the inside are enameled. Other portions of the inner surface are left unenameled, so that the scrap may make contact with the basket. The object of the application of the vitrious enamel is to make the outside surface of the basket inert; if this is not done it will act as anode and oxygen will be developed. By enameling it the number of ampere-hours required to detin a certain amount of scrap will therefore be reduced. In order to also reduce the voltage of operation the inventor endeavors to diminish the resistance of the cell by increasing the surface of the cathode using either a corrugated plate or a plate in form of a comb. A form of apparatus suitable for use in a continuous detinning operation is shown in vertical and hori-

zontal cross-section in Fig. 2. I is a stationary basket through which a conveyor runs, consisting of bars K carried by chains L. The outside of the basket I is covered with the insulating enamel E. The inner surface of the sides I' (made of sheet iron) is also covered with the vitrious enamel E, while the inner surface of the ends I³ of cast iron is left uncoated. The chains and the cross bars of the conveyor are also left uncoated. Between the legs of the basket I a corrugated electrode N is placed, while on each side of the basket I two comb-formed electrodes N' are placed, all of which are connected to the negative pole.

Coating Lace with Metal.—J. A. Daly, 844,304, Feb. 12. Application filed Oct. 15, 1901.

The object is to electroplate the finest laces and gauzy fabrics with metal of uniform thickness. The lace is stretched on a frame and the fibers are then covered with a thin, even coating of shellac. The shellac is thoroughly dried and serves to stiffen the lace. When dried the surface is covered with an aqueous solution of nitrate of silver and allowed to partially dry, but before the silver nitrate has thoroughly hardened the surface is again painted with an aqueous solution of potassium sulphide. Decomposition results, yielding silver sulphide and potassium nitrate. The lace is now washed in water which removes the soluble potassium nitrate, leaving the lace covered with a coating of silver sulphide, which is a conductor of electricity. This coating of silver sulphide is comparatively inert and will not destroy the fiber of the lace. The lace is then suspended by a number of wires in a plating bath and electroplated for a few minutes to receive a thin preliminary coating. The lace is then immersed in an alkaline bath to neutralize any acid remaining. It is then washed. The lace is then stretched out and brushed over on both sides with a scratch brush to combine the crystalline metal of the deposit more closely together and to the fibers of the lace. A simple metallic connection is now required, only to get the electrodeposit of metal to the desired thickness. When it is desired to retain the lace in flexible condition the first step of coating the lace with shellac is dispensed with and the nitrate of silver is applied directly to the lace.

Electroplating Apparatus.—H. R. Boissier, 843,321, Feb. 5. Application filed Nov. 25, 1905.

The electroplating apparatus consists of a tank with a shaft fixed at a point of its bottom and moveable in a conical path within the tank. On this shaft is fixed the receptacle which contains the articles to be plated. By a simple mechanical mechanism the shaft and the receptacle are put into the desired motion.

Water Purifying Apparatus.—J. McL. Murphy, 844,167, Feb. 12. Application filed Oct. 6, 1906.

Like in various other water purifying apparatus, the one described in this patent employs aluminium electrodes. The

FIG. 3.—WATER PURIFIER.

special object of the construction is to prevent the corrosion of the aluminium electrodes without counteracting their purifying action or the desired formation of the oxyhydrate of aluminium in the menstrum or interfering with the desired carbonic acid formation, due to the intermixing of the anodic oxygen gas with the carbonaceous organic matter in the water. The construction is shown in Fig. 3. B is the feed pipe through which the water enters the space S. It then passes through long, narrow spaces, each being formed between a positive electrode c and a negative electrode c' into the space S', and then leaves the apparatus. All electrodes are resting in grooves in the bottom of the tank, and are supported by means of hooks on two metal rods, one being connected to the positive pole, the other to the negative pole. By means of set screws c^x they are firmly clamped to the rods. The electrodes consist of 95 per cent aluminium and 5 per cent magnesium; the addition of magnesium is stated to prevent undue corrosion of the electrodes. The baffle plate 15 behind the discharge end of the feed pipe serves to distribute the water properly over the whole cross-section of the tank.

Water Purifier.—A. E. Dieterich, 844,262, Feb. 12. Application filed Oct. 3, 1906.

The water first passes through a mechanical filter where those impurities are removed which are in suspension. It then enters an electrolytic purifier intended to precipitate those impurities held in solution. The water finally passes through a second filter which serves to remove those suspended impurities precipitated by the electrolytic purifier. The electrolytic purifier comprises an insulating housing, in which is arranged a pair of aluminium electrodes, so designed and correlatively arranged as to form a zigzag water passage from the inlet to the outlet end. An automatic circuit controller is arranged for the circuit of the electrolytic purifier; by means of this automatic controller the circuit is closed by the water pressure before the water passes into the electrolytic purifier.

Primary Batteries.

Primary Battery.—Frank A. Decker, 842,867, Feb. 5, 1907. Application filed July 14, 1906, and 842,945, Feb. 5, 1907. Application filed Feb. 1, 1906. (Two further patents relating to the Decker primary battery, which was already noticed in our Vol. IV., p. 441, and our Vol. V., p. 58.)

Patent 842,867 refers to the construction of the battery "with an auxiliary bottom disposed within an envelope and connected, through the bottom of the envelope, with an exterior member, by means of which a conduit or conduits without the envelope is connected to and communicates with a conduit or conduits within the envelope." The envelopes are of lead, separated by insulating material, while the auxiliary bottom and the exterior member are preferably of hard rubber, vulcanized together through holes in the bottom of the envelope, so that a firm, tight and insulating construction is produced.

Patent 842,945 refers to the construction of a carbon electrode made by moulding and baking or graphitizing, with a corrugated or indented body with borders and transverse ribs reinforcing it. The top of the plate is enlarged either by flanging or gradual thickening.

Battery Receptacle.—H. B. R. L. Poerscke and G. A. Wedekind, 843,549, Feb. 5, 1907. Application filed July 25, 1904.

The patent refers to receptacles for elements made of cast iron, bronze, copper or steel, the walls and partitions of which are so shaped as to afford support to the oxidizing agent, for example, oxide of copper. The first claim reads as follows: "The battery-container electrode, having walls of cast iron bulging outwardly to coöperate with the opposite electrode, a plurality of dovetailed holding projections formed on the inside of said bulging walls and hardened, coherent copper oxide material on said walls engaging said projections forming a substantially flush surface."

Battery Cell.—H. Gernsback, 842,950. Feb. 5, 1907. Application filed June 25, 1906.

The patent refers to a method of assembling a greater number of cells in one group. The inventor spaces the cells apart so as to have an air space between them, in order that there will be no electrical transmission between the cells in case of a defect in the making and also to provide a suitable carrying-handle without needing a carrying-receptacle for the

cells. Between two cells spacing blocks are provided near the top and near the bottom edges of the cells, and between these spacing blocks a rod is inserted which has ends projecting outwards so as to fasten a strap on it on which the cells may be carried.

New Chemical Works.

The F. J. Stokes Machine Co., manufacturers of chemical and pharmaceutical machinery, are now occupying the new plant in Philadelphia which they have built and specially designed for their use. The building is situated on the corner of Seventeenth and Cambria Streets, a short distance from the North Philadelphia station of the Pennsylvania Railroad. The main building measuring 45 x 125 feet, includes a machine shop equipped with a traveling crane of 3-ton capacity, running the entire length of the shop; the front of the building, which is two stories high, being occupied as offices, drafting room and testing laboratory for experimental work in chemical processes, particularly that of vacuum drying, impregnating, etc.

FACTORY OF F. J. STOKES MACHINE CO.

A well-furnished lavatory for employees is situated in the basement in the front of the building, and is equipped with washstands, metal lockers and other conveniences.

The shop equipment consists of the usual lathe, planers, grinders, milling machinery and drill presses necessary for carrying on light and heavy machine work.

Power for operating the shop is supplied by a crude-oil engine of the Hornsby-Akroyd type, built by the De La Vergne Machine Co., of New York City. This also furnishes electric light.

The adjoining illustration shows a general view of the shop, which lacks that characteristic feature associated with older plants of this type—the tall smokestack

The F. J. Stokes Machine Co. are known throughout the chemical trade of the world as manufacturers of chemical and pharmaceutical apparatus, and have recently taken up the manufacture of vacuum apparatus for drying and impregnating. The modern facilities at their disposal enable the economic construction and erection of heavy apparatus

Copper and Silver-Lead Ores.—Catalog 6 of the Power & Mining Machinery Co., of Cudahy, Wis., gives an excellent, concise and well-illustrated review of modern methods of roasting, smelting and refining copper and silver-lead ores.

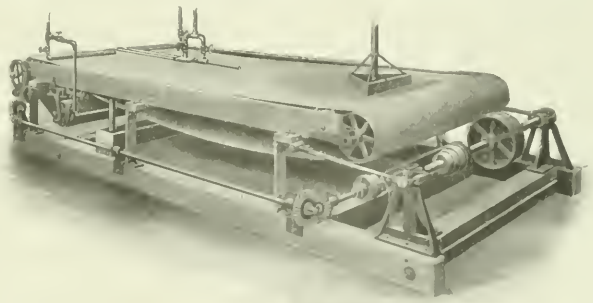
Slime Concentrator.

The great need of a slime concentrator that would save the maximum amount of slimes in a concentrating plant, and at the same time be simple in construction and easy of operation, has always been recognized by mill operators, wherever the practice of concentration of ores is carried on. The adjoining illustration shows such a machine and one that is entirely new in the field of slimers. In its design and construction are embodied features differing widely from anything heretofore introduced in concentrators of this class.

It is the joint invention of Messrs. Randall P. Akins and James P. Evans, both of whom have been for a long time connected with the Colorado Iron Works Co., and are well known as experienced mill builders. For nearly a year past, since the machine assumed its present form, it has been subjected to almost continuous work on all classes of concentrating ores, demonstrating daily its efficiency and superiority beyond peradventure of doubt under varied and actual service conditions.

As will be seen by the illustration, the Akins & Evans slime concentrator is of the traveling belt type, with a longitudinal or endwise shake. It is provided with a roller or drum at each end, also a wash roller and a take-up roller below the deck. These rollers serve the purpose in their respective places of carrying, imparting the travel to, washing, taking up and adjusting the true travel of the belt. These operating features are in a measure similar to those of a frue vanner, but there the similarity with that and other machines ends. The great advantage of the machine lies in the form or contour of its deck, which will readily be understood from an examination of the illustration with the following brief description:

The triangle shown is the pan or depression and the feed and settling space, the forward lines of which are substantially



SLIME CONCENTRATOR.

level: the central line extending from the settling space to the discharge end of the machine is the apex, and is the high line or portion of the deck from which and from the forward lines of feed and settling space the deck slopes forwardly and sidewise to the waste launders on each side. The belt is preferably of canvas or duck surface and of sufficient flexibility that in passing or being "drawn" over the deck it conforms to the contour thereof, maintaining perfectly the form of the pan or depression into which the slime pulp is distributed from the feed box. The water in the pan becomes comparatively quiet and the mineral constantly has an opportunity to settle, aided by the gentle reciprocal end-shake,

ed is thus caused to adhere firmly to the surface of the belt

The pan or depression is so shaped that as the heavy mineral settles, the lighter material is thrown by the motion of the table and gradually drawn by the travel of the belt toward the discharge point of triangular feed and settling space so that the tendency is for the lighter material to come on the deck proper at the beginning of the apex, where it is gradually washed toward the sides by a series of jets of water from a longitudinal and horizontal perforated pipe about 20 inches long, placed immediately above the deck at the beginning of the apex.

Following this pipe along the apex there is a similar one extending to the discharge end which supplies wash water to the deck. Two independent wash-water pipes are placed near the two corners at the discharge end, which have an adjustable sweep for further cleaning the concentrates when necessary.

The overflow from the feed and settling space over its level forward edges is uniform and thin, as is also the flow over the sloping sides of the machine with the added wash water, which gives the maximum opportunity to settle any agitated mineral that may be traveling with the gangue toward the waste launders.

The concentrates, as will be premised, are carried over the end of the machine with the travel of the belt, which, passing under the wash roller below the deck in water in the concentrates box, are washed off by the reciprocal motion of the table, aided, if necessary, by jets of water supplied through a perforated pipe playing on the belt as it comes out of the water.

In this way a clean belt is constantly presented as it continuously enters the feed and settling space at the head of the deck.

The mechanical features of the machine are simple, easily assembled and cared for when in operation. The deck or top is supported by six flat oak or hickory legs, 4 inches wide and 1_4 inch thick at thinnest part. These legs are amply strong, and while supporting the top and preventing any side sway, are sufficiently flexible to allow of an easy reciprocal motion to the top.

The main drive shaft is located at the head or feed end, and is fitted with cranks on each side, from which lead two side rods, which in turn are attached to the deck near supports under the head end and which impart the reciprocal motion or end shake. On the drive shaft are tight and loose pulleys to receive the drive from the mill shaft. The tight pulley is cast heavy and also serves as a balance wheel, giving steadiness to the motion of the table. A four-step cone pulley on this shaft is belted to a similar one on a counter shaft on the supporting frame.

A pair of bevel gears engages and transmits the power from the counter-shaft through the long side shaft to the discharge end of the table, where, by means of cut gears which allow for the motion of the table, it is communicated to the roller at the discharge end by a worm and worm wheel, which in its turn imparts the travel to the concentrator belt, the speed being adjusted by shifting the belt on the cone pulleys. The travel of the belt is approximately 26, 33, 43 and 56 inches, respectively, per minute, as governed by these step-cone pulleys, at a speed of 225 revolutions per minute of the drive shaft.

The drive shaft can be run up to 250 revolutions per minute, however, without disadvantage, and on some ores to advantage.

Ample means are provided for adjusting the belt so that it will run true and also for taking up the stretch.

The wearing parts are few and the belt will last a long time, and with ordinary care the machine cannot get out of order.

The floor space occupied is 7 by 16 feet, or about the same as any standard concentrator, and less than 1 hp. is required for operation.

Notes.

American Electrochemical Society.—The next annual meeting will be held on the 2d, 3d and 4th of May (Thursday, Friday and Saturday of the first week of May) in Philadelphia. The professional sections will be held at the University of Pennsylvania. We understand that the local committee is already very active to make the meeting a notable one and to insure a full success. Not only the present president, Mr. Carl Hering, but the secretary, Mr. S. S. Stadtler, and the treasurer, Mr. P. G. Salom, are Philadelphians. This will be the second general meeting to be held at Philadelphia, the first one being the inaugural meeting, held April 3, 4, 5, 1902, at which the Society was founded.

New Members of American Electrochemical Society.—At the February meeting of the Board of Directors the following gentlemen were elected members of the American Electrochemical Society: S. T. H. Hall, Helena, Mont., and J. Henry Lienau, New York. The names of the following gentlemen will come up for election at the March meeting: R. D. Thomas, Oakmont, Pa.; Chas. H. Kerr, Niagara Falls, N. Y., and E. O. Dillon, Bloomington, Ind.

New York Section American Electrochemical Society.—On the evening of Feb. 26 an extremely interesting section meeting was held, at which Prof. Lucke, of Columbia University, presented an elaborate paper on the comparative cost of electric power from water, oil, gas and steam. The paper elicited a long discussion, in which the remarks of Mr. Stott, of the power plant of the New York Subway, Mr. Herreshoff, of the General Chemical Co., and Dr. Baekeland were specially interesting. Mr. M. U. Schoop, of Paris, exhibited some interesting samples of aluminium articles welded by his autogenous welding method (our Vol. IV., p. 338).

Philadelphia Section American Electrochemical Society.—The March meeting of the Philadelphia Section was held in Soulas' café, Fifth and Ludlow Streets, preceded, as usually, by an informal dinner.

Electrochemical Development in Kentucky.—It is reported that plans are being formulated for an extensive water-power development on the Cumberland River, near Corbin, Ky.; 20,000 hp. shall be first developed, and most of this is intended to be used in a works for the electrolytic production of aluminium. At present the Pittsburg Reduction Co. is the sole producer of aluminium in this country, and is protected in its monopoly until 1909 by the Bradley patent. By that time the new company hopes to be ready for work.

Iron and Steel Institute.—The annual general meeting of the Iron and Steel Institute will be held on May 9 and 10, at the Institution of Civil Engineers in London.

Fire at Niagara.—On the afternoon of Feb. 25, the works of the Acker Process Co., at Niagara Falls, were destroyed by fire. One life was lost, that of Henry S. Fairchilds, an electrician, who was caught under the falling walls. With the collapse of the buildings which, it is understood, are a total loss, several cables from the power houses were town down. The total loss is estimated at about $800,000.

The Virginia Electrolytic Co., the formation of which, with offices at 97-103 Cedar Street, New York City, was recently recorded in our columns, has its plant located at Holcomb's Rock, Va. It controls at that point the entire flow of the James River. The electrical installation is now about 1,800 hp., and more is to be installed shortly. The property formerly belonged to the Willson Aluminium Co., which company has a larger plant at Kanawha Falls, W. Va. The new company was created by a separation of interests, including property, processes and patents. It is operated independently of the other plants. The list of products, including ferro-alloys, metallic silicon, sodium, calcium and magnesium, indicates that the company occupies a very interesting and unique field.

Lehigh University.—At the celebration of Washington's Birthday at Lehigh University, South Bethlehem, Pa., the honorary degree of Doctor of Science was conferred on Arthur Arton Hammerschlag, Director of the Carnegie Technical Schools of Pittsburg, Pa. The orator of the day was Hon. W. U. Hensel, of Lancaster, Pa., ex-Attorney-General of Pennsylvania.

Concrete Construction.—At the smoker of the Chemists' Club, of New York City, on Feb. 2, Mr. Richard L. Humphrey lectured on modern concrete construction, with special reference to the San Francisco earthquake.

The Willson Aluminium Co., of New York City, have removed their offices from 99 Cedar Street to 79 Wall Street.

Messrs. Fred. Bertuch & Co., of New York City, have received the order for the stoneware and porcelain supplies to be installed in the new Mint at San Francisco.

The Buffalo Dental Manufacturing Co., of Buffalo, N. Y., has just issued a new edition of their catalogue B of laboratory and workshop appliances (list No. 34 1907). A comparison of this new catalogue with former editions is evidence of the progressiveness of this concern.

Cupola Linings.—The Harbison-Walker Refractories Co., of Pittsburg, has just issued a small but very suggestive pamphlet, entitled "A Little Talk on Brick for Cupola Linings," which contains much practical and useful information for foundry men. We intend to refer to some interesting points in detail in our next issue.

Carbon Dioxide Recorder. The business hitherto carried on by Mr. John A. Caldwell, New York, in fuel-saving devices, including the widely known "Ados" CO_2 Recorder, has been merged into the Sarco Fuel Saving & Engineering Co. This company has taken over the American interests of Sanders, Rehders & Co., Ltd., fuel-economy specialties, of London and Manchester, and to manufacture on this side their various apparatus.

Electroquartz.—We have received from Wilson-Maculen Co., of New York City, some notes on their "electroquartz," a pure silica product of the electric furnace which has all of the properties of the very costly product made from rock crystal except transparency. Fused silica is milky white. Concerning further properties reference may be made to page 67 of our February issue. The Wilson-Maculen Co. keep in stock pyrometer tubes (closed at one end), tubes (open at both ends), pipes, plates, muffles, crucibles and dishes of fused silica. Another novelty which this company is now placing on the market in this country are Bunsen burners entirely of porcelain. These are the only Bunsen burners that can be easily kept clean.

The Kny-Scherer Co., department of laboratory supplies, 225-233 Fourth Avenue, New York City, is the consolidation of the old Kny-Scherer Co. and the Laboratory & School Supply Co., of New York, and the American representative of the well-known firms of Dr Peters & Rost and Max Kaehler & Martin's, of Berlin. The company deals in all kinds of chemical apparatus and laboratory supplies and makes a specialty of completely furnishing and equipping laboratories for educational institutions, technical schools, agricultural experiment stations, chemical works and factories. Two catalogues recently issued by the company are extremely handsome and valuable: these are catalogue 54, on apparatus for physiological, pathological, bacteriological and other clinical laboratories, and catalogue 60, on general chemical and scientific apparatus. Supplementary list 61 deals with lecture, physicochemical and electrochemical apparatus, supplementary list No. 62 with apparatus for practical and agricultural chemistry.

Electrochemistry in Italy. The Società Italiana di Elettrochimia, of Rome, which was formed several years ago by, among others, the Baden Aniline Works, and by Swiss financiers, holds concessions for the utilization of considerable water powers in central Italy, including the power of the rivers Tirino and Pescara. The first station in the Pescara Valley is expected to be started in a few weeks from the present time, the plant comprising five generating sets of 2,800 hp. According to the London *Electrical Review* a total of 6,000 hp. has already been contracted for by the Aluminium Co., the Società Prodotti Azotati, and the Società Abruzzese, which have also been constituted with the participation of German capital. It is also proposed to utilize the power of the second and third falls of the Pescara River, which will yield from 22,000 to 29,000 hp. The work for the extension of the factory for the production of electrolytic products is progressing, and will be finished in 1907. As the demand for chlorine manufactures is limited, it is not intended to extend the branch, as was originally contemplated, but to devote attention to other products. The Società Prodotti Azotati has completed its installation for the output of copper sulphate and mineral superphosphate, etc., and the factory for calcium cyanamide is already partly in operation. The Aluminium Co. expects to start its operation during this month, and all branches of manufacture will then be taken up. The share capital of the parent concern of the three companies—the Società Italiana di Elettrochimia—now amounts to $2,700,000, in addition to $600,000 in obligations, and the net profits realized in 1905-6 reached $153,500, as compared with $155,000 in the preceding year. A dividend at the rate of 6 2-3 per cent has just been declared for 1905-6, being the same rate as was paid for the previous twelve months. According to the *Chemiker Zeitung*, the Societa Elettrochimica del Caffro, founded by Asha, Curletti & Zironi, has completed its plant and has started operation on a large scale, making caustic soda by the "Kellner process as modified by Solvay." In an apparatus of their own construction the caustic soda solution is concentrated to 38° to 40° Baume. This solution is sold instead of solid caustic soda, since, especially if the consumer is not very far from the producer, the price is considerably reduced when complete evaporation is unnecessary. The company treats common salt from Sicily, about 20 tons being worked up in 24 hours. The new Società Elettrochimica Mouzene has started the manufacture of barium salts and silicates by a new electrolytic method. The Società Italiana Prodotti Azotati has started its new plant at Bologano, in which not only calcium cyanamide but also sulphuric acid and copper sulphate are made in large quantities.

Ferro-Phosphorus.—In a recent consular report we find a statement of Consul D. W. Harris, of Cardoff, concerning ferro-phosphorus, which is used to make steel roll with a better finish. It was first made by "a Liverpool firm" to supply an American demand, where ferro-phosphorus is used in the basic steel process for enriching the slag. In steel for sheet purposes, particularly tin plates, steel with phosphorus rolls with a better finish. Some rails high in phosphorus have been remarkable for their long life. It has also been found that under certain conditions carbon and phosphorus may replace each other. (For further details see the statement of George G. Blackwell Sons & Co. the Liverpool firm referred to on page 243 of our Vol. IV.) In the same note it is stated that "in the way of pig metal there was iron with a 7 per cent element of phosphorus produced at one time in the Thomas furnaces at Seaton Carew, in Durham. It is claimed also by a leading writer that phosphorus pig metal is produced in large quantities from the manganiferous brown ores containing phosphorus at Ilsede in Hanover. Pig iron produced in old Bloomery furnaces in Ohio, contained much phosphorus."

Portland Cement Industry. An account of many things of interest to the manufacture of American Portland cement is the recent formation of the Universal Portland Cement Co., a new subsidiary interest of the United States Steel Corporation, which has taken over the cement departments of the Illinois Steel Co. at South Chicago and Buffington, Ind., and of the Carnegie Steel Co. at Universal, Pa.

cement plant at Universal, which is being equipped at the present time, will be driven by means of electrical energy transmitted over 8 miles from the Homestead works of the Carnegie Steel Co., where a 4,000-kw. Allis-Chalmers gas-engine-driven electric generating plant is to be installed. Units of this type, aggregating 35,500 kw. in capacity, have been ordered by the Steel Corporation for various of its mills. Of the cement making machinery now on order for installation at Universal, a line of nine Gates ball mills, supplied by the Allis Chalmers Co., will be prominent.

Colorado College. We have received from the Colorado College a pamphlet containing the paper by L. C. Lennox and Chas. N. Cox, Jr., on the fusibility and fluidity of titaniferous silicates, which was published in our issue of December last, under the title "Tests of Titaniferous Slags," and a paper by Vernon T. Brigham, on the design of a low-tension switchboard. These are two theses submitted to the faculty in Colorado College in 1906. This pamphlet forms the first issue of the Engineering Series of the Colorado College Publication.

Messrs. Smith, Emery & Co., chemists and chemical engineers, who, after the complete loss by fire of their former offices in the San Francisco disaster, have been occupying temporary quarters at 1068 Broadway, Oakland, will move into their new building, corner of Howard and Hawthorne Streets, San Francisco. This building has been specially designed and erected for its purpose, and will give first-class office and laboratory facilities.

Personal.

Messrs. Waller & Renaud, consulting chemists, electrochemists and metallurgists, of 159 Front Street, New York, announce that their Mr. Henry Stanley Renaud, B. S., L.L. B., has been admitted to the bar and will conduct in future the legal department of the firm.

Prof. Rutherford of McGill University, has been appointed to be the successor of Prof. Schuster at the University of Manchester, England.

Dr. Jean Billitzer, of the University of Vienna, is traveling through this country to study large-scale electrochemical developments.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

Carborundum (*Concluded.*)

No. 527,826, Oct 23, 1894. E. G. Acheson, of Monongahela City, Pa.

Electric-arc pencils, consisting of finely pulverized carbon 90 per cent, silicon carbid 10 per cent. and tar, compressed, baked and coated in the usual manner. Or the rod may consist of a tube of carbon filled with silicon carbid with or without a binder. Incandescent filaments may be coated with silicon carbid, by suspending the finely powdered carbid in the oil bath used for treating and building up filaments, the amount of carbid deposited being governed by the amount in suspension. The silicon carbid is said to be valuable not only on account of its infusibility and inertness toward oxygen, but by producting a greater number of light-waves for the same energy than other illuminating bodies.

No. 564,219, July 21, 1896. F. E. Parks, of Homestead, Pa.

Adds to molten steel, at or after the end of the refining operation, a relatively small amount of silicon carbid. The carbid, in the proportion of from 6 to 8 ounces per ton of steel, may be enclosed in a small packet and thrown into the mold while the ingot is being poured. Silicon carbid thus added in the mold to "dead soft steel in hot and wild condition, tapped from an open-hearth furnace," quiets the steel and produces an ingot having a solid top, practically free from sponginess or piping. The carbid may be added to steel in the ladle, at the end of the refining operation, though its addition in the mold is preferable. Manganese and other usual agents may be added with the silicon carbid.

No. 585,036, June 22, 1897. A. E. Hunt, of Pittsburg, Pa.

Adds to molten steel a small quantity of silicon carbid, for example, 5 pounds of carbid to 3,000 pounds of steel. The carbid may be placed in a paper envelope and added to the steel in the ladle, before, with, or after the usual addition of ferromanganese, or, for large ingots or castings, it may be added to the molten steel as it is poured into the mold. It may also be added to the bath of metal in a Bessemer converter, increasing, by its oxidation, the heat and fluid of the metal. Silicon carbid added to ingots of soft steel increases the percentage of carbon and thereby the tensile strength, adds silicon, a portion only of the silicon being oxidized, and quiets the metal, the casting being sounder and more perfect, its surfaces solidifying more quickly, thus diminishing oxidation of the iron by the action of air on the boiling metal, reducing the amount of "crop" to be removed from the top of the ingot after rolling or forging, and permitting the ingot to be stripped from the mold more quickly and in a hotter condition. Silicon carbid is an efficient substitute for ferrosilicon as a means for adding silicon, and is preferable as practically free from phosphorous. It does not lower the melting point of iron or steel, though it readily gives up its silicon and carbon to the metal. It may be used with ferromanganese, decreasing the required amount of the latter. It has a softening effect when added to cast iron.

No. 615,648, Dec. 6, 1898. E. G. Acheson, of Buffalo, N. Y.

Produces wheels, bricks, blocks and crucibles of carborundum by moistening crystalline carborundum in grains of the desired size with a solution, preferably saturated, of sulfate of iron, molding under pressure and firing in a kiln. The iron sulfate is thereby decomposed and the iron peroxid reacts on the silicon carbid to produce an iron silicate binder. For the production of very strong articles, iron peroxid, in powdered form, or ores or clay rich in iron oxid, are mixed with the carborundum crystals. Iron and its compounds do not form a satisfactory bond for amorphous carborundum. A small amount of crystalline carborundum, say from 2 to 10 per cent, is therefore added to amorphous carborundum, in order to bond it with iron sulfate or oxid.

No. 628,288, July 4, 1899. Benjamin Talbot, of Pencoid, Pa.

Employs silicon carbid, either crystalline or amorphous, for the production of firebrick, linings for furnaces and converters, crucibles, molds and other purposes employing high temperatures and destructive slags. The carbid is preferably ground, mixed with tar, molasses, pitch or rosin, or with caustic lime or magnesia, or plastic clay and water. It may be molded into bricks and fired, or merely placed in a metallurgical structure and there dried and burned. The carbid should be free from silica to prevent fluxing by basic slag, but may contain graphite. The nature of the binder is determined by the slag to which the material will be subjected. Linings may be repaired by applying the pulverized dry or moistened carbid.

No. 650,040, May 22, 1900. E. W. Engels, of Essen, Germany.

Renders bricks, plates and other materials fire and acid-proof by coating them with a carbid, especially carborundum. The carborundum may be applied to the brick and fused and united therewith by an electric arc of 200 amps. at 110 volts. Or a mixture of sand and charcoal may be applied to the surfaces of the bricks and subjected to an electric arc of sufficient intensity to produce carborundum therefrom and cause it to unite with the material of the bricks. The bricks may be of any usual material, for example, silicious or clayey substances.

NEW BOOKS.

The Manufacture of Metallic Articles Electrolytically.—Electro-engraving. By Dr. W. Pfanhauser. Authorized English translation by Joseph W. Richards, M. A., A. C., Ph. D., professor of metallurgy at Lehigh University. 172 pages, 100 illustrations and many tables. Price, $1.25 net. Easton, Pa.: The Chemical Publishing Co.

Lehrbuch der Elektrochemie. By Max Le Blanc. Fourth edition, 319 pages, 25 illustrations. Price, bound, marks 7; in New York, $2.35. Leipzig: Oskar Leiner.

The Electrolytic Dissociation Theory.—By Prof. R. Abegg, Ph. D. Translated by Carl L. von Ende, Ph. D. 189 pages. Price, $1.25 net. New York: John Wiley & Sons.

Electrochemistry.—I. Theoretical Electrochemistry and its Physico-chemical Foundations. By Dr. H. Danneel. Translated from the Sammlung Goeschen by Edmund S. Merriam, Ph. D. 181 pages, 18 figures. Price, $1.25 net. New York: John Wiley & Sons.

Notes on Construction in Mild Steel.—Arranged for the use of junior draftsmen in the architectural and engineering professions, with illustrations from working drawings, diagrams and tables. By Henry Fidler, M. Inst., C. E. 448 pages, 425 illustrations in text. Price, 10s. net; American price, $5.00 net. London, New York and Boston: Longmans, Green & Co.

Uber das Gleichgewicht und die Erstarrungsstrukturen des Systems Eisen-Kohlenstoff.—By Carl Benedicks. 33 pages, illustrated. Halle, a. S.: Wilhelm Knapp.

On the Theory and Practice of Art Enamelling Upon Metals.—By H. H. Cunningham, C. B. 188 pages, illustrated American price, $2.00 net. London: A. Constable & Co. New York: The Macmillan Co.

Analysis, Detection and Commercial Value of the Rare Metals.—A treatise on the occurrence and distribution of the rare metals and earths, the methods of determination and their commercial value in the arts and industries with an historical and statistical review of each. By J. Ohly, Ph. D. Third edition. 290 pages. Price, $3.00 net. Denver, Col.: The Mining Reporter Publishing Co.

Gold Mining Machinery, its Selection, Arrangement and Installation.—A practical hand-book for the use of mine managers and engineers, including particulars for the preparation of specifications and estimates. By W. H. Tinney. 308 pages, 97 illustrations, mostly in the text. Price, $5.00 net. New York: Van Nostrand Co.

Inorganic Chemistry for Schools and Colleges.—By James Lewis Howe, Washington and Lee University. (A second edition of inorganic chemistry according to the periodic law, by F. P. Venable and J. L. Howe.) 422 pages, 70 illustrations in the text. Price, $3.00 net. Easton, Pa.: Chemical Publishing Co.

Inorganic Qualitative Chemical Analysis for Advanced Schools and Colleges.—By William Stowell Leavenworth, M. Sc., professor of chemistry Olivet College. 160 pages with illustrations and many tables. Price, $1.50 net. Easton, Pa.: The Chemical Publishing Co.

Allen's Commercial Organic Analysis.—A treatise on the properties, modes of assaying and proximate analytical examinations of the various organic chemicals and products employed in the arts, manufactures, medicine, etc., with concise methods for the detection and determination of their impurities, adulterations and products of decomposition. By Alfred H. Allen, F. I. C., F. C. S., past president Society of Public Analysis. Vol. II., part III.: Acid Derivatives of Phenols, Aromatic Acids, Resins and Essential Oils. Third Edition, by A. H. Allen and A. R. Tankard. Price $5.00 net. Philadelphia: P. Blakiston's Son & Co.

Combustion and Smokeless Furnace.—By Joseph W. Hays. 104 pages, 15 text illustrations. Price, $1.50. New York: Hill Publishing Co.

Electric and Magnetic Measurements and Measuring Instruments.—By Frank W. Roller, M. Am. Inst., E. E. 398 pages, 312 text illustrations. Price, $3.50 net. New York: McGraw Publishing Co.

Concrete Factories.—An illustrated review of the principles of construction of reinforced concrete buildings, including reports of the sub-committee on tests, the United States Geological Survey and the French rules on reinforced concrete. Compiled by Robert W. Lesley. 152 pages, numerous illustrations. Price, $1.00. Published for *Cement Age* by Bruce & Banning, New York.

Concrete and Reinforced Concrete Construction.—By Homer A. Reid. 884 pages, 715 illustrations in the text. Price, $5.00 net. New York: The Myron C. Clark Publishing Co.

Handbook of Mathematics.—For engineers and engineering students. By J. Claudel. Translated and edited by Otis Allen Kenyon. 708 pages. Price, $3.50. New York: McGraw Publishing Co.

The Engineering Index.—Vol. IV. Five years, 1901-1905. Edited by Henry Harrison Suplee and T. H. Cuntz, in cooperation with Charles Buxton Going. 1,234 pages. Price, $7.50. New York and London: *The Engineering Magazine.*

BOOK REVIEWS.

German Monographs on Applied Electrochemistry, Vols. XVIII to XXIV. Wilhelm Knapp, Halle.

Vol. 18: *Elektrolytische Verzinkung.* By Sherard Cowper-Coles. Translated into German by Dr. Emil Abel. 8vo., 38 pages. Price, 2 marks; in New York, $0.70.

This is a short but very practical description of electrolytic zinc plating (galvanizing). Rather disappointing is the fact, however, that the author gives the minimum of information drawn from his own successful experience, and the maximum concerning the more or less unsuccessful attempts of others. We are left with the impression that the author has hardly given his readers "a square deal," although the work is not by any means without value.

Vol. 19: *Die elektrolytische Chloratindustrie.* By John B. C. Kershaw. Translated into German by Dr. Max Huth. 8vo., 124 pages, 39 illustrations. Price, 6 marks; in New York $2.00.

The author of this satisfactory review of the chlorate industry was concerned with the ordinary chemical production of chlorate for ten years and now adds to that experience a wide knowledge of electrochemical processes. The work is thus more original and valuable than some other of these monographs which consist largely of extracts from patent specifications without intelligent review or criticism. This is a well written and interesting monograph from beginning to end.

Vols. 20, 21, 22: *Die Elektrolyse geschmolzner Salze.* By Richard Lorenz. I: Verbindungen und Elemente. 8vo., 208 pages, 9 illustrations. Price, 8 marks; in New York, $2.05. II: Das Gesetz von Faraday, die Ueberführung und Wanderung der Ionen, das Leitvermögen. 8vo., 243 pages, 59 illustrations. Price, 8 marks; in New York, $2.05. III: Elektromotorische Kräfte. 8vo., 315 pages, 75 illustrations. Price, 10 marks; in New York, $3.35.

This monumental work deserves a place alongside of Faraday's "Experimental Researches," for in the 765 pages of text, every page of which is carefully and skillfully written, probably more than half is the record of the laboratory work of the author, carried out either alone or in cooperation with his students. Each of the three parts is worthy of a separate review, and would receive it were it not that the mass of new material each contains could scarcely be mentioned, let alone properly appreciated, in the space at our disposal. The style

JUST PUBLISHED

12mo. Cloth 498 Pages Price, $2.50 Net

Van Nostrand's
CHEMICAL ANNUAL

A Hand-book of Useful Data
for Analytical, Manufacturing and Investigating Chemists, and Chemical Students

Based on Biedermanns' "Chemiker Kalender"

EDITED BY
Prof. J. C. OLSEN, A.M., Ph. D.
Polytechnic Institute, Brooklyn
Formerly Fellow Johns-Hopkins University
Author of "Quantitative Chemical Analysis, by Gravimetric, Electrolytic, Volumetric and Gasometric Methods."

With the Co-operation of Eminent Chemists

FIRST YEAR OF ISSUE, 1907

The absence of a comprehensive reference book of numerical data of the Science, has induced the publishers to undertake the publication of this Annual, which it is their intention to issue, with new data added, annually.

IN PRESS

8vo. Cloth About 350 Pages

SOLUBILITIES
OF
Inorganic and Organic Substances

A Hand-book of the most
Reliable Quantitative Solubility Determinations

COMPILED BY
ATHERTON SEIDELL, Ph.D. (J.H.U.)
Bureau of Chemistry, U. S. Department of Agriculture

The principal features which have been emphasized in the preparation of this volume are as follows:

Completeness of Data
Uniformity of Expressing Results
Selection of Most Reliable Determinations
Arrangement of Material

D. VAN NOSTRAND COMPANY
Publishers and Booksellers
23 Murray and 27 Warren Sts., New York

is clear and interesting, the treatment systematic and complete, and the whole done with such evident command and mastery of every detail of the subject as to render its reading a keen pleasure. We will simply say to our readers that this work is one of the classics of electrochemistry, and should be within hand's reach of every electrochemist.

Vol. 23: *Elektrolytische Alkalichloridzerlegung mit flüssigen Metallkathoden.* By Dr. R. Lucion. 8vo., 204 pages, 181 illustrations. Price, 9 marks; in New York, $3.00.

There are some brief introductory chapters on the principles of alkali chloride electrolysis with liquid metallic cathodes. But the bulk of the book is simply a list of German, English, French, Belgian and United States patents relating to this subject, with extracts from the patent specifications. 178 pages of the book deal with mercury-cathode processes, 24 pages with processes using a molten cathode (lead). The book contains very little that is novel or original with the author; it gives essentially extracts without critical discussion.

Vol. 24: *Die elektrochemischen Deutschen Reichspatente.* By Dr. P. Ferchland und Dr. P. Rehländer. 8vo., 230 pages, 124 illustrations. Price, 9 marks; in New York, $3.00.

The first author has compiled the patents on inorganic electrochemistry, the second, those on organic. The chapters taken in order, cover the light metals, alkaline salts and halogen elements, hypochlorite, oxidized salts, alkaline earths, carbides, decomposition of water, ozone, nitrogen compounds, heavy metals, compounds of heavy metals, apparatus, electrodes, diaphragms, furnaces, miscellaneous; anilines, benzines and their intermediate products, para amido phenol, organic dyes and their intermediate products, pharmaceutical products and miscellaneous organic compounds. Some 600 patents in all are noticed, with an average of ten lines to each. This is very brief space in which to give the essentials of a patent, but those which we have examined closely, as tests, seem to be intelligently and skillfully abstracted. A first-class index—is missing.

* * *

Lead Smelting and Refining. Edited by W. R. Ingalls. 8vo., 321 pp., 51 illustrations. Price, $3. New York and London: *Engineering and Mining Journal.*

This is a reprint of various articles which have appeared in the *Engineering and Mining Journal* and *Transactions of the American Institute of Mining Engineers* during the last three years, classified by the editor of the first-named journal, and we must not omit to say that twelve out of the fifty-two articles reprinted are from Mr. Ingalls' own facile pen.

The subjects are classified under ten parts (*chapters* might have been the more suitable term), treating of lead mining (28 pages), roast-reaction smelting (20 pages), sintering and briquetting (22 pages), blast-furnace smelting (47 pages), lime roasting of galena (102 pages), other smelting methods (14 pages), dust and fume recovery (21 pages), blowers and blowing engines (12 pages), lead refining (27 pages), smelting works and refineries (37 pages). As is seen from this schedule, the lime roasting of galena rightly receives the lion's share of attention, while blast-furnace smelting comes next.

The impression made by the collection, as a whole, is that the information is first hand, intensely practical and indispensably valuable to any one concerned in any way with knowing the present metallurgy of lead. Take Hofman's unsurpassed "Metallurgy of Lead," last edition, add to it this volume, and the sum is the sum total, the last word which has been said, on present methods of lead smelting.

The typography is clean, the binding attractive, but not strong enough; the book deserved to be printed on better paper.

* * *

Van Nostrand's Chemical Annual. 1907. Edited by John C. Olsen, A. M., Ph. D. 12mo., 496 pages. Price, $2.50. D. Van Nostrand Company, New York.

This is the first issue of an annual intended to make acces-

sible to chemists the chemical data of most use to them, brought up to date. A. F. Seeker contributed tables on "Oils, Fats and Waxes"; E. E. Reid and C. A. F. Kahlbaum on "Physical Constants of Organic Compounds"; A. Rogers and V. J. Chambers a "Review of Literature and New Books of Organic and Industrial Chemistry"; J. L. Morgan a similar review relating to physical chemistry; G. B. Pagram a similar treatment for "Radioactivity," and C. H. Lips a "Review of New German Books." The rest of the contents are by Prof. Olsen. The various chapters are on the physical constants of the elements, calculations of volumetric analyses, calculation of gas analyses, calculation of gravimetric analyses (each accompanied by useful tables and logarithms), physical constants of inorganic and organic compounds (240 pages), specific gravity and vapor tension tables, and thermochemistry. Nearly 60 pages are devoted to a list of important articles and books in chemistry since Jan. 1, 1905.

All the chapters are satisfactorily done except thermochemistry. Here only the constants concerned in the combustion of carbonaceous fuels are given and no other of the various heats of chemical combination, not even the newly determined ones. Further, the heats of combustion are the laboratory values, to liquid water, instead of the practical values to vapor of water.

The work is beautifully printed; the frontispiece is a fine portrait of Ramsay. The intention is expressed in the preface of enlarging the scope of the annual, in future issues, if the demand justifies it. We hope it will.

* * *

THE CHEMISTRY AND TECHNOLOGY OF MIXED PAINTS. By Maximilian Toch, director of the laboratory of Toch Bros., New York City. 166 pages with 60 photomicrographic plates and other illustrations. Price $3.00 net. New York: D. Van Nostrand Co.

This is the first book ever published on the subject of mixed paints or paints ready for use. The manufacture of mixed paints is essentially American, and it is most fortunate that the author of this first book is probably the foremost authority on paints in this country, being not only a paint manufacturer of highest standing, but a wideawake chemical engineer. Mr. Toch is at present the president of the Chemists' Club of New York.

The general scope of the book is indicated by the statement of the author that "the volume is intended for the student in chemistry who desires to familiarize himself with paint, or the engineer who desires a better knowledge of the subject, or for the paint manufacturer and paint chemist as a work of reference. It is not intended for those who have no previous knowledge or training in the subject."

Mr. Toch's book appears just at the right time in view of the rapidly increasing uses of mixed paints. "One of the railroads of the United States buys at this writing upwards of one million dollars worth of paint material per year, a large share of this being mixed paints, or paint ready for the brush. Nearly all of the large manufacturing industries which use large quantities of paint are gradually altering their methods so that their paint comes to them ready for application. In no case, to the best knowledge of the author, does a single one of these industries prescribe a single pigment reduced with linseed oil for general purposes, for it has been shown that a mixture of several pigments and a filler is superior from the standpoint of lasting quality and ease of application to a mixture of a single strong pigment and the vehicle."

It is very interesting to learn that the structural iron industry, which has reached an enormous development in this country, uses paints ready mixed with the one exception of red lead, which, in the old prescription of 33 pounds of red lead to 1 gallon of oil, cannot be prepared ready for the brush.

The manufacture of agricultural implements, wagons and wire screens can be cited as industries in which manufacturers have within a very few years adopted the use of ready-mixed

Volume II, Part III, NOW READY

ALLEN'S

Commercial Organic Analysis

A TREATISE ON THE PROPERTIES, MODES OF ASSAYING, AND PROXIMATE ANALYTICAL EXAMINATION OF THE VARIOUS ORGANIC CHEMICALS AND PRODUCTS EMPLOYED IN THE ARTS, MANUFACTURES, MEDICINE, ETC., WITH CONCISE METHODS FOR THE DETECTION AND DETERMINATION OF THEIR IMPURITIES, ADULTERATIONS, AND PRODUCTS OF DECOMPOSITION.

By ALFRED H. ALLEN, F. I. C., F. C. S.

Past President, Society of Public Analysts; formerly Public Analyst for West Riding of Yorkshire, the City of Sheffield, etc.

Volume II, Part III

Acid Derivatives of Phenols, Aromatic Acids, Resins and Essential Oils

Third Edition

Rewritten and Revised by the Author and

ARNOLD ROWSBY TANKARD, F. C. S.

Member of the Society of Public Analysts

8vo. Cloth, net $5.00

P. Blakiston's Son & Co., Publishers
1012 Walnut Street, Philadelphia

Handbook of Mathematics

FOR ENGINEERS AND ENGINEERING STUDENTS

By J. CLAUDEL

Translated and Edited from the Seventh French Edition by OTIS ALLEN KENYON

A complete book on Mathematics
It covers very thoroughly
Every branch from Arithmetic to Calculus

TABLE OF CONTENTS

PART I.—ARITHMETIC. I.—Fundamental Operations on Whole Numbers. II. Properties of Whole Divisors. III.—Fractions and Decimal Numbers. IV.—Powers and Roots. V.—Ratios, Proportions, Progressions. VI.—Diverse Rules. VII.—Logarithms. PART II.—ALGEBRA. I.—Of the Four Fundamental Algebraic Operations. II.—Equations of the First Degree. III.—Powers and Roots of the Algebraic Quantities. IV.—Equations of the Second Degree. PART III.—GEOMETRY. Plane Geometry. Solid Geometry. Problems in Geometry. PART IV.—TRIGONOMETRY.—Plane. Spherical Trigonometry. PART V.—ANALYTICAL GEOMETRY. PART VI.—CALCULUS. I.—Differential Calculus. II.—Integral Calculus. III.—Applications of Integral Calculus.

Cloth, 708 Pages. 422 Illustrations. Price, $3.50 Net.
Sent anywhere postpaid for the price
Send Us Your Inquiries Write For Our Catalogs

McGraw Publishing Company
PUBLISHERS, IMPORTERS AND BOOKSELLERS
114 Liberty Street, New York

JOHN WILEY & SONS

Scientific Publishers

43 and 45 EAST 19th STREET

NEW YORK CITY

NEW BOOKS

The Electrolytic Dissociation Theory

By Prof. R. Abegg, Ph.D., of the University of Breslau. Authorized Translation from the German by Carl L. von Ende, Ph.D., Assistant Professor of Chemistry, State University of Iowa.

12mo, vii + 189 pages Cloth, $1.25 net.

Electrochemistry

I—Theoretical Electro Chemistry and its Physico-chemical Foundations. By Dr. Heinrich Danneel, Privatdozent of Physical Chemistry and Electro chemistry in the Royal Technical High School of Aachen. Translated from the Sammlung Göshen by Edmund S. Merriam, Ph. D., Associate Professor of Chemistry in Marrietta College, Ohio.

12mo, vii + 181 pages, 18 figures. Cloth, $1.25 net.

Ask for our Catalogues and Circular Matter on Chemical Books

NOTES ON

Electrochemistry

By F. G. WIECHMANN, Ph.D.

CLOTH 150 PAGES PRICE $2.00 NET

CONTENTS

I.—General Principles
II.—Electrical Energy
III.—Electrochemistry
IV.—Electrolytic Dissociation
V.—Electro-Analysis
VI.—Electrotechnology

"The principal aim kept in view in the preparation of this book has been the giving of a clear and concise presentation of the general principles which underlie electrochemical science.

"Endeavor has been made to meet the needs of students entering upon the study of electrochemistry and of chemists interested in the application of electrical energy to chemical problems.

"Prefacing each chapter is a bibliography of important treatises bearing upon the subject matter discussed in it."

Postpaid on Receipt of Price

Write for Catalogs Send Us Your Inquiries

McGRAW PUBLISHING CO.

Publishers, Importers and Booksellers

114 LIBERTY STREET NEW YORK

paints for their products. These paints are not brushed on, but are so scientifically made, and the difference between a vehicle and a pigment is so carefully observed, that large pieces of their products are dipped into troughs and the paint allowed to drain. The surface is more evenly coated, and the work done in far less time that would be required were it applied by means of the brush as in former years.

Mr. Toch makes a strong plea for professional honesty and courage on the part of the paint manufacturer, who should not hesitate to state openly the results of his researches even if they will interfere with old prejudices. The paint manufacturer should stand back of his products—irrespective of the prejudice of others—provided his new products be mixtures of materials which time, science and investigation have proven to be superior.

After an introductory chapter on the manufacture of mixed paints there follow five chapters on pigments: white pigments, oxides of lead, red pigments, yellow, blue and green pigments. This is followed by a discussion of inert fillers and extenders (silica, infusorial earth, china clay, kaolin, barium and calcium salts) and of paint vehicles (linseed oil, Chinese wood oil, turpentine, benzine, benzol), with notes on the effect of water in the composition of mixed paints. The book is concluded by two chapters on special paints (floor paints, cement paint, damp-resisting paints, paints for breweries) and on the analysis of mixed paints.

Every page of Mr. Toch's book is evidence that the author gives the results of his own experience. The book thus has a decided personal element in conception and presentation, and is representative of the best tendencies in modern chemical engineering. In view of the great importance of paints for all constructing engineers, the book cannot fail to make many friends.

* * *

Radioactive Transformations. By E. Rutherford, D. Sc., etc. Price, $3.50 net. Charles Scribner's Sons, New York.

While the author in this book, which contains his Silliman lectures, gives some account of the general phenomena of radioactivity, this is only done in so far as is necessary for an understanding of the real object of the work—a study of the transformations which are continuously taking place in radioactive matter. Thus we have chapters on "Radioactive Changes in Thorium," "The Radium Emanation," "Transformation of the Active Deposit Radium," "Origin and Life of the Radium," etc.

One of the most interesting chapters is the last one on the "Physical View of Radioactive Processes." Here Dr. Rutherford considers the various hypotheses used in the study of radioactive phenomena and we are glad to observe that he refers to certain absurd notices about these modern discoveries that are current in some quarters: "It has been incorrectly assumed by some that the study of radioactive phenomena has tended to cast doubt on atomic theories."

The futility of the various systems of philosophy so far as a knowledge of the ultimate reality of things is concerned has been so deeply impressed on the minds of many people that they are prone to consider that philosophical speculation is nothing more than a waste of time. But if the study of philosophy has no other value, at least it impresses on the mind the relativity of knowledge and helps to prevent a hard, mechanical conception of such useful hypotheses as that of Dalton. It in no wise lessens the value of Dalton's hypothesis that we may now find it convenient to liken the atom to an onion, or to suppose that it is a structure built of electron bricks cemented with a mortar of positive electricity. No one supposes that if he could see an atom it would look like an onion any more than it would smell like one, and if, to-morrow, someone observes a new phenomenon which makes it useful to liken an atom to an elephant, it will not involve a "revolution" in scientific thought.

Electrochemical and Metallurgical Industry

VOL. V. NEW YORK, APRIL, 1907. No. 4.

Electrochemical and Metallurgical Industry

With which is Incorporated Iron and Steel Magazine

Published on the first of each month by the
ELECTROCHEMICAL PUBLISHING COMPANY,
[*Incorporated.*]
114-118 LIBERTY STREET, NEW YORK.

J. W. RICHARDS, PH. D. ..... *President*
E. F. ROEBER, PH. D. ..... *Editor*

Subscription Price: $2 per year, postpaid to any part of the world. Single copies 25 cents.

Copyrighted, 1907, by the Electrochemical Publishing Co.

Entered as Second-Class Matter, June, 1903, at the Post-Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, APRIL, 1907.

CONTENTS.

EDITORIAL 113
Berthelot 113
The Negatives in Storage Batteries 113
The Bessemer Steel Process 114
Philadelphia Meeting of the American Electrochemical Society 116
The Iron and Steel Market 116
Toronto Meeting of the Canadian Mining Institute 117
New York Meeting of the American Institute of Mining Engineers and the Dedication of the Engineering Society Building 118
CORRESPONDENCE:
Tilting Electric Steel Furnace 118
The Structure of Wrought Iron. By Albert Sauveur 119
Blast-Furnace Top Construction. By J. Kennedy 120
Compound Steel—A Modern Steel Plant Proposition. By Peter Eyermann 122
The Osmotic Pressure before the Faraday Society 125
Professor Henri Moissan. By R. S. Hutton and C. A. Doremus. 127
Iron and Steel Statistics 129
Metallurgical Calculations (Open Hearth Steel). By J. W. Richards 129
Magnetic Separation of Iron Ores by the Gröndal Process. By P. McN. Bennie 134
The Open-Hearth Steel Process. By T. Naske 139
NOTES ON ELECTROCHEMISTRY AND METALLURGY IN GREAT BRITAIN. 140
ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS 149
SYNOPSIS OF CURRENT PERIODICAL LITERATURE 141
RECENT METALLURGICAL PATENTS 148
Laboratory Induction Furnace 151
Ball Filling Material for Sulphuric Acid Towers 151
Zinc and Lead in Upper Missippi Valley 152
Brick for Cupola Linings 152
NOTES 153
DIGEST OF UNITED STATES PATENTS 154
NEW BOOKS 155
BOOK REVIEWS:
Schnabel and Louis' Handbook of Metallurgy 155
A. Humbolt Sexton's Corrosion and Protection of Metals 155
W. Ostwald's Conversations in Chemistry 156
M. LeBlanc's Lehrbuch der Elektrochemie 157
J. Allen's Some Founders on the Chemical Industry 158
J. Claudel and O. A. Kenyon's Handbook of Mathematics 158

Berthelot

At this place we spoke in our last issue of the loss of Mendeleeff, Moissan and Roozeboom. We have now to record the tragic death of M. Berthelot, a few moments after that of his loved wife. Unlike his compatriot, Moissan, Berthelot was not solely a scientist, but he took a part—and a very active part—in the public political life of France. Yet the grand work of his life related to thermochemistry. The two big volumes in which his experimental determinations of heats of reaction are collected, form a "monumentum aere perennius." They will make the name of Berthelot immortal. It would be useless to dwell any further on the value of his experimental work. But a few words may be said on its relation to thermodynamical theory.

* * *

When we speak of the heat of a chemical reaction, we really mean the energy of the reaction, measured (arbitrarily) in heat units. We can get this energy completely in the form of heat; or we can get it, at least partly, by means of electrochemical processes, in form of electrical energy; or, for instance, by employing expanding gases, we can get it partly in form of mechanical work. In any case the total energy of reaction is the same, whatever may be the way in which we force the reaction to go on. This is the principle of the conservation of energy. Whenever we want to employ this principle—for instance, for giving the heat balance sheet of a chemical or metallurgical process—we need numerical data for the energies of reaction such as Berthelot has determined. This indicates the enormous field of their applicability. But it also indicates the limitations, although Berthelot has maintained a different view on this point for a long time. The principle of the conservation of energy does not state anything whatever concerning the direction in which a reaction will go on. Berthelot, however, believed in the "principle of maximum work"—that if a reaction shall go on at a certain temperature, it is necessary that this reaction shall evolve heat. We know now that pronounced in such generality this rule is wrong. We know now that if we want to find out something on the direction in which a process will go on, we must start from the entropy principle instead of the energy principle, we must know the free energy, not the total energy of reaction. Nevertheless, the strict principle will resolve itself practically into Berthelot's rule for reactions of great intensity and at low temperatures (including our ordinary temperature). It is for this reason that although wrong in its foundation, Berthelot's rule may be usefully employed for many practical purposes.

◆◆◆

The Negatives in Storage Batteries

"Many are called but few are chosen." The number of battery inventions and patents is legion. But very few only have marked important industrial progress since the days of Planté. It is, therefore, a pleasure to call attention to one patent of Mr. Joseph Bijur, abstracted in the "Analysis of Current

Electrochemical Patents" in our present issue, since it may be conservatively said that the process described in it looks very promising. It serves the highly useful purpose of preventing the loss of capacity of the negatives (spongy lead plates) in the lead storage battery. For many years the life of a lead cell has been limited by the condition of its negatives. The loss of capacity of the negatives in time during service is a fact. It is a condition, not a theory. As a remedy, negative plates after having lost part of their capacity have been used as positives (peroxide plates) and have thus recovered. But this needs careful and skilled attendance. It is just as if a physician treats his patient at periodical intervals with medicines and thus relieves temporarily the trouble without removing the real underlying cause of the disease. What then is the cause of the trouble with the negatives?

* * *

The chemical reaction which yields the electric current takes place at the contact surfaces of the active-mass particles with the acid in its pores. The active mass with its containing electrolyte is the stomach, heart and soul of the battery. The electrolyte outside of the pores represents only a reservoir of food, from where a fresh supply is dispatched when needed to the place where it is needed, that is, into the pores within the active mass. It is, therefore, an essential necessity that the active mass be thoroughly porous and remain so during service. On the other hand, for simple mechanical reasons, the active mass must be hard, tough and coherent, able to withstand expansion and contraction; it must be firmly attached to the support of the plate so that no particles may drop off or insulating sulphate layers form between support and active mass. These two fundamental conditions—porosity and tough coherency of the active mass—appear to be contradictory, and their simultaneous fulfillment represents an important problem of storage battery manufacture. In the case of the negatives, the loss of capacity may be due to the formation of the insulating sulphate layer mentioned above (especially in pasted plates), or to the dropping off of active material from the grid. But even if care is taken in the construction of the plate to prevent this to occur, there has, nevertheless, always occurred a loss of capacity, due to a contraction of the pores of the mass; the pores contract, the plate shrinks, it loses its porous consistency and solidifies partly into solid lead. This means, of course, an enormous reduction of the active surface, which directly explains the loss of capacity. The problem is, therefore, briefly, to maintain the porous consistency of the plate during service. For plates of the Faure-Brush type experience has shown that it is possible to use a certain composition of the paste, having a tendency rather to expand than to shrink. In an analogous way the problem has been attacked by the European Tudor Co's and the Electric Storage Battery Co. of Philadelphia, which in their "box-plate" employ a very porous active mass of high expanding power and prevent the active mass from dropping off by means of a perforated lead wrapper cast together with the grid. In its results the box-plate meant an important achievement, since with it the negatives have a longer life than the positives.

* * *

Mr. Bijur attains the same end in a peculiarly direct manner. He reinforces the porous structure of the active mass by means of inert matter, just as concrete buildings are reinforced with steel. His plate has a solid metallic support as foundation, and upon it is built a porous structure of particles of active mass, reinforced by carbon particles which are chemically inert, and serve the sole purpose of holding the active-mass particles in their original condition of porous consistency. The idea is beautifully simple. But the means to attain this end would appear at first sight extremely difficult. As a matter of fact, however, the real remarkable feature of Mr. Bijur's process is the extreme simplicity and directness by which he introduces the reinforcing carbon particles afterwards, after the plate has been formed, by introducing sugar and carbonizing it. It is clear that if too much carbon is introduced in this way the carbon will clog the pores and will make matters worse. To be efficient the carbon particles introduced must be just enough to give sufficient strength to the structure, but they should not reduce in any essential degree the active surface of the lead particles. From the fact that the method has been in practical use for a year it appears that Mr. Bijur has found the exact conditions of accomplishing his end. The method certainly deserves most careful attention.

The Bessemer Steel Process

About 12,250,000 gross tons of Bessemer steel ingots were produced in the United States in 1906, with a small tonnage of Bessemer steel castings, made from the various forms of baby converters. The production of Bessemer steel in the United States has been doubling through successively lengthening periods. There is every reason to believe that the 1906 production will never be doubled. The first year, 1867, for which statistics were gathered showed a production of 2,679 gross tons. In 1875 the production was 335,283 gross tons. From that year it has required the following periods for a doubling of production. Three years to 1878, three years to 1881, six years to 1887, eight years to 1895, and finally eleven years to 1906. In the early years new plants were built with avidity. Not all of them were entirely successful. Some were poorly located and others were insufficiently financed. There is no necessity to recount the early history of the Bessemer steel process in this connection. The later history, say from 1890 to the present, is of quite a different tenor. There has been relatively very little of building of absolutely new plants, but an enormous advance in the actual production of given plants. Occasionally new plants have been built, but with the completion last summer of the Youngstown Sheet & Tube Co's plant at Youngstown, Ohio, it is quite possible that the building of entirely new plants has absolutely ceased. Not until now has a really successful steel enterprise abandoned a Bessemer plant, but that spectacle is to be presented within a few months, when the Carnegie Steel Co. tears out its Bessemer department at Duquesne, to make way for the eighteen basic open-hearth furnaces it has already started to build, as an addition to the already large open-hearth department at Duquesne.

* * *

The year 1890 is a good selection for comparison with the achievement of last year, since in 1890 the regular Bessemer process had been well worked out, the Clapp-Griffiths and Robert-Bessemer processes were distinctly on the decline, and

direct metal was not being used regularly, although it came into vogue within a couple of years thereafter. We make, therefore, a comparison of Bessemer converters and actual production in 1890 and in 1906. It is impossible to be certain, at this late date, that every one of the converters entering into our 1890 table was actually in operation during the year, but if any were idle the result is not seriously affected. No doubt, on the other hand, enters into the 1906 table; all the converters which it comprises were in operation practically through the year, with the exception of two 10-ton vessels which began operations in August. The 1890 statistics of production excluded the Clapp-Griffiths production, but included the Robert-Bessemer. We have made a suitable deduction for the production by this latter process, arriving at a production, by regular Bessemer converters, of 3,580,000 gross tons of Bessemer steel ingots in 1890. The Clapp-Griffiths and Robert-Bessemer converters are not included in our table for 1890. There were eleven 3-ton and two 2-ton Clapp-Griffiths converters in that year, with one 5-ton, three 2-ton, six 1½-ton and one 1¼-ton Robert-Bessemer converters, a total rated converter capacity by the two processes of 581¼ tons. For 1906 we have made a suitable deduction for the production of Bessemer steel castings, and have correspondingly eliminated all the small converters used for the production of castings. This cuts the standard Bessemer converter capacity off with the two 4½-ton vessels operated at Columbus, the smallest converters now in use for the production of Bessemer steel ingots.

Standard Bessemer Converters Operative in 1890.

Number.	*Rated Capacity.*	*Total Capacity.*
2	11½	23
16	10	160
2	9	18
5	8	40
10	7	70
7	6	42
19	5	95
6	4	24
7	3	21
2	5	10
1	1	1
77		504

Standard Bessemer Converters Operated in 1906.

Number.	*Rated Capacity.*	*Total Capacity.*
3	18	54
9	15	135
4	12½	50
32	10	320
4	8	32
2	7	14
2	6	12
2	5½	11
2	5	10
2	4½	9
62		647

Summary.

	1890.	1906.
Average rated capacity per converter..	6.55	10.44
Total ingot production in gross tons...	3,580,000	12,250,000
Average output in tons per converter..	46,493	197,580
Average output per ton of rated converter capacity.....	7.103	18.934

Three chief causes have contributed to the increase in output, relative to rated converter capacity, an increase which has amounted to 167 per cent in sixteen years. The first has been the introduction, at nearly all important works, of the direct metal process with the Jones mixer. The second has been improvement in the auxiliary equipment, necessitating less waiting on the part of the converter. The third has been a more general realization of the economy in forcing production to the utmost. With direct metal and a mixer hotter and more uniform pig iron is furnished the converter, permitting the use of iron with lower silicon content. There is the curious spectacle of standard Bessemer pig iron being defined in contracts to-day as to contain between 1 and 2 per cent of silicon, while in the large steel works the metal used averages less than 1 per cent in silicon. The iron which is sold runs much nearer to 1 per cent than to 2 per cent, and would not lead to further purchases if it hugged 2 per cent. Naturally, the supply is more dependable with the mixer than when, as formerly, cupolas were used exclusively. The auxiliary apparatus has been improved at many points. The machinery of the converter itself is better, while soaking pit capacity has been greatly increased; interruptions to rolling are less serious, and the increased soaking pit capacity smooths off the irregularities that still come, to a greater extent than formerly.

* * *

The tendency to push all capacity to the utmost is such a feature of American steel works operation that it need not be referred to in particular as to its influence in bringing up the output of converters. There was curious reading for American steel works managers two or three years ago, when a history of a "Bessemer shop" in England was given to the Iron and Steel Institute. The writer described how the output per converter had been steadily increased, so that the management found it "could get along" with a much decreased number of converters, and the useless excess was dismantled. An American manager can hardly sleep well if he finds his whole plant is balanced, except that the shear could do more work than it is called upon to perform. He wants to bring the other departments up. There is no likelihood of any important Bessemer steel works being built in the United States in the future. As already noted, a really successful Bessemer department is scheduled for abandonment, the first case of the sort. Others may follow. The output of the existing plants may be increased somewhat, but the blowing operations are already conducted with almost clockwork regularity, the blast furnace has been made completely the servant of the steel works, to furnish exactly the analysis of pig iron required, and there is apparently but little more that can be done. The pneumatic vessel may not disappear, but may, on the contrary, increase in numbers. It is being put to the, perhaps, base use of constituting an adjunct to the regular basic open-hearth process, by being made to partially desiliconize and decarburize metal preparatory to more complete treatment, and dephosphorization on the open-hearth. The system has been very successful at Ensley, Ala. Probably the principal factor in the extension of this system will be the rate of growth of the demand for steel. With a very rapid growth the scrap outcome will not be sufficient to reduce carbon by mixture, while with a slower growth of demand scrap will come out in steadily increasing quantities, relative to the demand.

Philadelphia Meeting of the American Electrochemical Society.

As previously announced, the sixth annual and eleventh general convention of the American Electrochemical Society will take place in Philadelphia on May 2, 3, 4. The sessions for the reading and discussion of papers will be held at the University of Pennsylvania.

The local Philadelphia committee is sparing no efforts to make this meeting particularly enjoyable. The president of the Society, Mr Carl Hering, the secretary, Mr. S. S. Sadtler, and the treasurer, Mr. Pedro G. Salom, are all of Philadelphia. This will be the Society's second meeting at Philadelphia. At the first one the Society was founded in the Spring of 1902.

Among the visits and excursions which have so far been arranged are the following: On one afternoon the buildings and laboratories of the University of Pennsylvania will be inspected. A visit will be paid to the plant of the United Water Improvement Company employing the method of sterilization of drinking water by means of ozone. The ozone is produced by silent electric discharges through air by the Vosmaer apparatus. The new United Staes Mint will be visited where the Wohlwill process of electrolytically refining gold, and the Tuttle process of electrolytically refining silver are in use. These two visits, together with an inspection of the Public Buildings (City Hall) will probably be the programme for the second afternoon, while on the same evening a banquet will be held.

For the third afternoon, excursions will be made to the works of Henry Disston & Sons, the well-known tool steel makers of Frankford. The most interesting modern feature of the works is probably the production of special steels in the electric induction furnace of Colby. The Frankford station of the Philadelphia Electric Co. and the Lardner's Point Pumping plant, all at Tacony, will then be visited. For this excursion a boat has been placed at the disposal of the Society. This excursion will be concluded in the evening by a shad dinner at Gloucester, N. J. For those few who may not know it, it may be said that shad dinners on the New Jersey side of the Delaware belong to the most delightful things which old Philadelphia has to offer to visitors in glorious Spring time.

Other excursions are being planned and the above list is merely given to show the probable course of events. Provision is being made for the entertainment of ladies, there being a great many points of interest in and around Philadelphia, such as Fairmount Park, the old State House, with the Liberty Bell, Carpenter's Hall, Old Christ Church, Franklin's grave, the Betsy Ross house, Old Sweeds Church. Excursions for members or ladies for some or all of these points will be arranged.

Among the papers promised for the meeting are the following:

E. Buckingham—The Present Status of the Thermodynamic Scale.

C. F. Burgess—Rapid Determination of Electrolyte Resistance.

G. K. Burgess—Determination of Fixed Points in Pyrometry.

F. A. J. FitzGerald and F. Forsell—On Carbons for Electrochemistry.

Gustave Gin—Electric Reduction of Titaniferous Iron Ores.

W. J. Hammer—Surface Properties of Aluminium and Zinc.

Carl Hering—A Practical Limitation of Resistance Furnaces; the "Pinch" Phenomenon.

W. McA. Johnson—The Electrometallurgy of Zinc, and its Relation to Present Practice.

A. T. Lincoln—Electrolytic Corrosion of Brass (1906 award for research).

Charles E. Lucke—Relative Cost of Power.

John Meyer—Reply to the paper presented by Mr. E. A. Sperry at the Ithaca meeting on Electrochemical Processes as Station Load Equalizers.

H. J. Parker—The Helion Lamp.

Henry Noel Potter—Bomb Calorimeter for Measuring the Heat of Combustion of Substances Giving Solid Oxidation Products.

C. J. Reed—Changes of Concentration and Migration Velocities.

C. J. Reed—Electrolytic Pickling of Steel.

J. W. Richards—The Work Done in Electrolysis.

E. P. Schoch and Alcan Hirsch—The Electrolytic Deposition of Nickel-Zinc Alloys.

E. F. Smith—Recent Developments in Electrolytic Analysis.

R. C. Snowden—Electrodeposition of Zinc.

S. A. Tucker—Boron Carbide.

D. K. Tuttle—Evolution of Modern Methods of Parting and Refining.

W. H. Walker—Influence of Strain on the Corrosion of Iron.

O. P. Watts—The Action of Carbon on Magnesia at High Temperatures.

J. A. Wilkinson and H. A. Gillett—Polarization Voltages of Silver Nitrate Solutions.

Other papers are expected from Professor C. F. Burgess, Mr. E. R. Taylor, Professor S. A. Tucker and others. Of course, the presidential address of Mr. Carl Hering will also be delivered at this meeting, while arrangements are being made for a special experimental lecture at one of the sessions.

The complete programme will be sent out by the secretary to the members early in April, and will be given in full in our next issue.

The Iron and Steel Market.

The little lingering doubt as to the near future of the iron and steel market should be removed by the continuance of heavy specifications against finished steel products and the purchase of some 60,000 tons of Bessemer pig iron for second quarter delivery at substantially the market for prompt delivery.

The developments do not affect the prospects of the market in the two or three closing months of this year and in 1908. That is still an unknown period, with the prospects remaining that the large increase in blast-furnace capacity discussed in detail in our last report will not be balanced by a sufficient increase in consumptive demand over what has existed recently, and still exists. Until about October or November next, the evidence is strong that high pressure will continue, and the latest developments only go to show that the transition from high pressure to insufficient pressure will be more sudden than had been anticipated.

The National Tube Co. has withdrawn all prices on merchant steel pipe, and will accept new business only for delivery after June 1, subject to such prices as may meanwhile be announced. Independent pipe makers have advanced prices one to two points, and the market on steel pipe is firm on the basis of an extreme discount of 75 and 5 per cent off list, an advance of about $2 a net ton in the month.

The American Sheet & Tin Plate Co. has extended through the third quarter, the period for which it will accept tin plate business at the ruling figure. The independent mills had anticipated an advance, and had been taking third-quarter business at 10 cents rise, guaranteed, as usual, against the price of the leading interest. The guarantee will thus cut off the advance in price written in the contracts.

A flood at Pittsburg broke the record of these rivers on March 15, causing a loss of from two to three days' time to most of the furnaces in the district, between 50,000 and 60,000 tons of pig iron, which loss is carried through steel mill and finishing operations, as blast-furnace production had been the

weakest link in the chain. The breaking of the flood record at Pittsburg was not due to altogether unprecedented meteorological conditions, but rather to the progress of forest denudation and the filling in of river banks by industrial operations. The Federal Government took this matter seriously in hand two or three years ago and has put itself in position seriously to resist further encroachment upon harbor lines.

Pig Iron.

The United States Steel Corporation has bought 11,000 tons of Bessemer pig iron from the Bessemer Furnace Association at $22, valley furnace, or $22.85, delivered, Pittsburg or Cleveland, and has taken an option on 14,000 tons for May delivery, which option is virtually a purchase, as it will, undoubtedly, be exercised. The corporation could well use a much larger tonnage, the significant fact being that it is willing to pay so high a price, possibly as much as $10 a ton above its own cost. The transaction cleans up various lots of early delivery iron, which otherwise might not have found ready sale and might have depressed prices. The position of the leading interest is doubtless that while it deprecated the advance in the pig-iron market to so high a figure, it prefers to support the position once it is established. The Cambria Steel Co. bought from W. P. Snyder & Co., 36,000 tons of Bessemer pig iron for equal monthly deliveries over the second quarter, on terms which amount practically to a sale at a flat price of $22, valley. Furnace interests will certainly not sell any Bessemer iron for delivery prior to July 1 at less than $22, and are likely to ask $22.50 for 1,000 to 5,000-ton lots, and $23 for less than 1,000-ton lots. Their position in asking, for months past, $21.50 for second-half iron is much strengthened, as the market is gradually approaching the second half, and remaining on a $22 basis. Foundry iron is stiffer. Small, prompt lots bring as high as $25, valley, for No. 2, while $23.50 is asked for second quarter. Second-half business is practically untouched in the north, with the strategic position of furnace improving week by week. The Southern pig-iron market shows a slightly better tone. The leading interests have been holding to $18.50, Birmingham, for second half, but there have been sellers, possibly on a speculative basis, at $18, and as it is now more difficult to get this $18 iron, the furnaces may possibly be able to establish their $18.50 position for the third quarter, if not for the entire half.

Steel.

The supply of crude steel in the market is reduced and the tone is stronger. The Carnegie Steel Co. has bought 5,000 tons of billets from the New York State Steel Co., a new interest which is just starting a 200-ton Talbot open-hearth furnace at Buffalo, N. Y., and building a blast furnace which should go into commission about Jan. 1 next. A transaction on 10,000 tons of billets was put through a few weeks ago between these interests. These purchases are of interest in the circumstances. The Carnegie Steel Co. will apply the material on its outstanding billet contracts, on which deliveries have been quite behind. The Jones & Laughlin Steel Co. is understood to have withdrawn as a seller of sheet bars, having booked all the tonnage desired at present. The Carnegie Steel Co. has again named $30 on sheet bars on monthly and quarterly adjustment contracts, this price having been put out first for September last on monthly contracts, and for the fourth quarter on quarterly contracts, the previous price having been $29. The company has canceled many of its contracts of this nature, but still has a large tonnage in force. Nominally, Bessemer billets are $29 f. o. b. mill; open-hearth billets are $30 to $32, mill, and sheet bars $30, Pittsburg or Youngstown.

Rails.

While it is well established that on account of greatly decreased borrowing power the railroads will be compelled greatly to curtail their purchases, the influence has not as yet been seriously felt. In but very few instances have postponements been asked, and cars, locomotives, rails, etc., now ordered will carry the steel industry along for six months or more. The Alabama, Colorado and Illinois rail mills are sold up for the entire year and are considering the opening of rail-order books for 1908 deliveries. The Eastern mills are well sold up. To Feb. 15 the Carnegie Steel Co. had sold of standard rails to domestic steam roads, for 1907 delivery, 446,497 tons, while it sold altogether of this class of business, for 1906 delivery, 454,851 tons. Within a few days after Feb. 15 it has sold enough additional tonnage to make the total exceed the entire 1906 business, while there is of necessity considerable business, in small lots, yet to be placed for this year. Its sales of standard rails to traction lines to Feb. 15, for this year's delivery, amounted to only 73,449 tons, against 156,824 tons booked for the entire year 1906, but the placing of this business is always done later, and there is time yet to equal the 1906 tonnage. To March 15 the total rail bookings of the company for 1907 delivery amounted to 745,000 tons, this being made up approximately as follows: Light rails (under 50 pounds), 40,000 tons; standard rails, domestic steam roads, 500,000 tons; traction lines, 75,000 tons; export, 130,000 tons. The price of standard rails remains at $28, mill, except that Colorado charges a higher price, and Alabama charges $29, mill, for its open-hearth rails. It is predicted that the Carnegie Steel Co. will be able to make open-hearth rails at Youngstown by Jan. 1 next, while the new Gary plant will be making rails by Feb. 1 or March 1.

Finished Steel.

There have been no important price changes outside of the advance in merchant steel pipe already mentioned. Galvanized wire products may possibly be advanced on account of the continued high price of spelter, while there may be another advance in galvanized sheets, relative to black. Some Eastern plate mills have reduced the premiums asked above the regular mill price, charged by reason of the earlier deliveries they can make. Premiums are occasionally paid on other products, above the regular mill prices, which are quoted below. Sheets frequently involve a premium of $2 a ton for shipment within a fortnight, while steel bars in the East are regularly at a premium for early delivery.

Structural shapes, $1.70 for beams and channels, 15 inches and under, angles and zees; $1.75 for tees; $1.80 for beams and channels over 15 inches.

Plates, $1.70 for tank quality, ¼ inch and heavier, 100 inches wide and less; flange, $1.80.

Merchant steel bars, $1.60, base.

Common iron bars, $1.80, delivered Pittsburg; for Western delivery, basis $1.65, f. o. b. Pittsburg.

Sheets, 28 gauge, $2.60 for black, $3.75 for galvanized.

Tin plates, $3.90 for 100-pound cokes.

Toronto Meeting of the Canadian Mining Institute.

The ninth annual convention of the Canadian Mining Institute was held at Toronto from March 6 to 8. Mr George R Smith, in his address as retiring president, reviewed recent progress in mining and metallurgy in Canada, especially in the province of Ontario, and notably in the cobalt district. The membership of the Institute has now passed the 500 mark.

A special feature of the proceedings was a discussion, extending over two afternoons, on the mining tax law pending in the Ontario Legislature. Two resolutions were adopted, both asking the Government for most careful consideration of the measure before making it a law.

The development of the cobalt district was discussed in several papers by Mr W G Miller, Prof C R Van Hise and Dr. Robert Bell. Most papers dealt with mining and geological subjects. Two interesting metallurgical papers were on the use of graphic formulæ for metallurgical calculations, by David H Browne, and on magnetic separation by the Gröndal

process by D. McN. Bennie. The latter paper will be found on another page of this issue.

The main social feature of the convention was a most enjoyable dinner on the evening of March 7. After the official close of the meeting at Toronto, a party of members, numbering more than fifty, made a two-day excursion to the cobalt district.

Mr. Frederick Keffer, of Greenwood, B. C., is the new president.

New York Meeting of the American Institute of Mining Engineers and the Dedication of the Engineering Society Building.

The ninety-second meeting of the American Institute of Mining Engineers will be held in New York City from Tuesday, April 16, to Saturday, April 20, 1907. The date of the meeting has been chosen to enable members to be present at the dedication and formal opening of the new Engineering Society Building, 29 West Thirty-ninth Street.

The full programme of the dedication exercises, on Tuesday and Wednesday, April 16 and 17, will be found below. The provisional programme for the meeting of the Institute of Mining Engineers on the following days, April 18 to 20, is as follows:

Thursday, April 18.—At the session of the American Institute of Mining Engineers in the afternoon, Mr. H. D. Hildage will present a paper on mining engineering operations in New York City and vicinity. This paper will describe the excavation and tunnel work now carried on by the transportation companies. In the evening of Thursday, at the session of the American Society of Mechanical Engineers, Brig.-Gen. William Crozier will present an address on the ordinance department of the engineering organization.

On *Friday*, April 19, a session of the American Institute of Mining Engineers will be held in the afternoon, which will be devoted to the reading and discussion of professional papers. In the evening an informal smoker with vaudeville will take place in the concert hall of Madison Square Garden for members of the three "Founder Societies."

On *Saturday*, April 20, in the afternoon, an opportunity will be given to a limited number of members to visit the tunnel work which will be described in Mr. Hildage's paper.

The programme of professional papers to be presented at the Mining Engineers' meeting is very long. On account of limitations of space we can only give a list of the papers on *metallurgical* subjects.

H. M. Howe—Piping and Segregation in Steel Ingots.

H. M. Howe and B. Stoughton—Wax Ingots Showing the Effects of Casting.

E. G. Banks—Grinding in Tube Mills at the Waihi Gold Mine, Waihi, New Zealand.

Mark R. Lamb—The Butters Slime Filter.

John J. Porter—The Occurrence and Effects of Zinc in the Iron Blast Furnace.

Robert H. Richards—The Velocity of Galena and Quartz Falling in Water.

H. O. Hofman, W. S. Caypless and E. E. Harrington—The Constitution of Ferro-Cuprous Sulphides.

A. L. Sweetser—Laboratory Tests in Connection with the Chlorination Process.

H. O. Hofman, R. P. Reynolds and A. E. Wells—Laboratory Experiments in Lime Roasting and Galena Concentrate with Reference to the Savelsberg Process.

H. M. Howe, William Campbell and C. W. Knight—The Roasting of Argentiferous Cobalt-Nickel Arsenides.

Woolsey McA. Johnson—The Physical Metallurgy of the Reduction of Zinc Oxide.

E. P. Mathewson—Relative Elimination of Iron, Sulphur and Arsenic in Bessemerizing Copper Mattes.

H. O. Hofman, R. Hayden and H. B. Hallowell—A Study in Refining and Overpoling Electrolytic Copper.

Frank Firmstone—An Early Instance of Blowing-in Without Scaffolding-Down.

Charles Catlett—Barium Sulphate Associated with Iron Ore Found in the Pinar del Rio Province of Cuba.

S. S. Wyer—Gas Producer Power Plant.

The programme for the first day dedicatory exercises of the Engineering Societies Building, on *Tuesday*, April 16, is as follows:

The exercises are appointed to commence at 3 P. M. with music. The meeting will then be opened by Mr. Charles Wallace Hunt, presiding officer, who will make the first use as a gavel of the setting maul employed by Mrs. Carnegie in laying the corner-stone of the building. Rev. Edward Everett Hale, chaplain of the United States Senate, will speak a prayer, and communications will be read from the President of the United States, the President of the Republic of Mexico and the Governor-General of Canada. Mr. Charles F. Scott, chairman of the conference and building committees, will then make an historical address, which will be followed by the acceptance of the building by Mr. E. E. Olcott, president of the United Engineering Society, representing the Founder Societies.

Mr. Andrew Carnegie, the donor of the building, will then make an address, which will be followed by music and an oration by President Arthur T. Hadley, of Yale University, on the professional ideals of the twentieth century.

On the evening of Tuesday a general reception will be held beginning at 9 P. M.

The programme for the second day, *Wednesday*, April 17, is as follows: The meeting to begin at 2.30 P. M. After an introduction by Mr. J. W. Lieb, Jr., chairman of the dedication committee, addresses will be presented by the presidents of the Founder Societies: Dr. Samuel Sheldon, president American Institute Electrical Engineers; Dr. F. R. Hutton, president of the American Society Mechanical Engineers, and Dr. John Hays Hammond, president of the American Institute Mining Engineers.

Greetings and felicitations will then be presented from foreign and national scientific societies and institutions of learning, whereupon Dr. James Douglas, past president of the American Institute of Mining Engineers, will make an address. The John Fritz gold medal will then be presented to Dr. Alexander Graham Bell by Mr. Charles F. Scott, chairman of the John Fritz Medal Board of Award.

Dr. A. R. Ledoux, past president of the American Institute of Mining Engineers, will then present medals for distinguished services to Mr. R. W. Pope, secretary of the American Institute Electrical Engineers; Dr. F. R. Hutton, past secretary American Society Mechanical Engineers, and Dr. Rossiter W. Raymond, secretary American Institute Mining Engineers.

CORRESPONDENCE.

Tilting Electric Steel Furnace.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—With reference to the paper by Mr. Roechling in your last issue, page 92, permit me to say that while the information on the results obtained in commercial practice with the induction furnace in Germany is highly interesting, yet the design of the tilting furnace is not as novel as the author appears to believe. It is true that Mr. Kjellin in his Norwegian furnaces used two tap holes. But the induction furnaces built in this country according to the designs of Mr. E. A. Colby (who is the original inventor of the induction furnace) have all been constructed as tilting furnaces. This is, for instance, the case for the one furnace in commercial use at the Disston Works in Philadelphia. A. N. H.

Philadelphia, Pa.

The Structure of Wrought Iron.

By Albert Sauveur.

It is proposed in this short article to describe the structure of wrought iron chiefly through the reproduction of the best and most typical drawings and photomicrographs of that metal which have appeared in various books and other publications. By doing this we shall bring together the work of different students of metallography and show in a forcible manner the certainty with which the structure of iron and steel can now be revealed and the close "check" obtained by independent workers. It is also our aim to illustrate and describe the structure of wrought iron in so simple and clear a manner as to leave a distinct impression of its apearance and significance in the mind of even the casual reader.

For the sake of simplicity and clearness we may, at the outset, consider wrought iron as being practically free from carbon, and we shall also ignore for the purpose of this article the presence of such impurities as phosphorus, sulphur, manganese and silicon. In short we shall consider wrought iron as a mixture of two constituents only, namely, (1) carbonless iron and (2) slag, which it essentially is.

Let us now examine the occurrence of these two constituents as revealed by the microscope.

Ferrite. Carbonless iron in metallography is called ferrite, a name which suggests its nature. An examination of the accompanying illustrations will show that ferrite occurs in the shape of well defined net works in polished and suitably etched sections of wrought iron. The meshes of these net works represent, of course, sections cut through small grains frequently referred to as "grains" or "crystalline grains." It will be noticed that these grains are roughly polygonal and frequently hexagonal.

The dark net work itself indicates the junction lines between adjacent grains and is made apparent by the etching operation, the acid acting around the grains more deeply than over their surfaces and in this way producing a difference in level resulting in the dark appearance of the junctions.

Each ferrite grain is not a true crystal, but is made up of a great many small cubic crystals, which in any one grain are always oriented in the same direction, but whose orientation changes as we pass from one grain to the next and the polyhedric contour of the grains themselves is due to these interfering small cubic crystals. Because of this difference in orientation of the small cubic crystals of various grains, some of these appear bright under the microscope, while others are dark, as plainly shown in Fig. 7. The reason is obvious; those grains which are so oriented that they reflect the incident light into the microscope will appear bright, while if the small crystals have such a direction as to reflect the light outside the instrument, the corresponding grain will appear dark. By slightly inclining the sample in various directions, some of the grains which were bright become dark, and vice versa, because in doing so we change the direction of the light reflected by each individual crystal and this kaleidoscopic effect affords a conclusive evidence of the accuracy of the explanation offered to account for the dissimilar appearance of the grains of ferrite. In order to produce this difference in coloration, however, it is necessary to etch relatively deeply, a slight etching resulting merely in outlining the junc-

Fig. 1.—Microstructure of carbonless and slagless iron (after J. O. Arnold). Magnified 400 diameters.

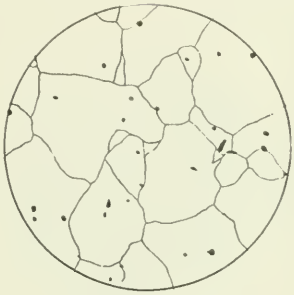


Fig. 2.—Transverse section of Swedish Lancashire hearth wrought iron (after J. O. Arnold). Magnified 460 diameters.

Fig. 3.—Transverse section of wrought iron (after Percy Longmuir). Magnification not stated.

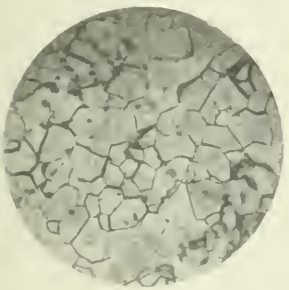


Fig. 4.—Transverse section of wrought iron (after H. C. Boynton). Magnified 80 diameters.

Fig. 6.—Longitudinal section of Low Moor wrought iron (after H. C. Boynton). Magnified 80 diameters.

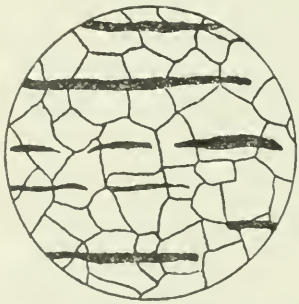


Fig. 5.—Longitudinal section of wrought iron (after Percy Longmuir). Magnification not stated.

tions, as it fails to bring out the internal structure of the grains.

Transverse and Longitudinal Sections.—By comparing Figs 1, 2, 3 and 4 with Figs. 5, 6, and 7, it will be seen that the appearance of ferrite is identical in both transverse and longitudinal sections; there is no indication of the ferrite being drawn in the direction of the rolling or forging. Both sections show equally well the decidedly crystalline nature of ferrite.

Slag.—The illustrations clearly show the way in which the slag occurs in the structure. In longitudinal sections it assumes the form of fibres, varying greatly in width and length,

FIG. 7.—LONGITUDINAL SECTION OF WROUGHT IRON (AFTER W. J. DEAN). MAGNIFIED 80 DIAMETERS.

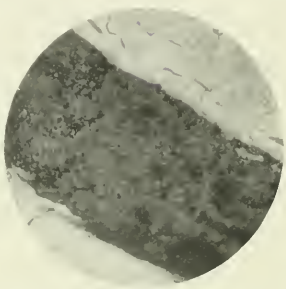


FIG. 8.—SLAG IN WROUGHT IRON, LONGITUDINAL SECTION (AFTER H. C. BOYNTON). MAGNIFIED 80 DIAMETERS.

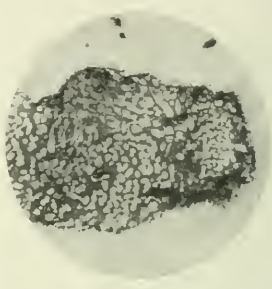


FIG. 9.—SLAG IN WROUGHT IRON (AFTER LEON GUILLET). MAGNIFIED 180 DIAMETERS.

but all running in a direction parallel to the rolling, while in transverse sections they occur as irregular dots, which, of course, correspond to cross-sections through the fibres shown in the longitudinal sections. It will also be noticed, especially in Figs. 8 and 9, that the slag is clearly made up of at least two components, probably two silicates, but whose nature has not yet been ascertained.

Fibrous Structure of Wrought Iron.—From the above description and accompanying illustrations it will be evident that the ferrite, of which wrought iron is composed, does not assume a fibrous structure, the slag alone being drawn into fibres. Wrought iron, therefore, should not be described as being fibrous, for, leaving aside the presence of slag it is as distinctly crystalline as steel. The general belief in the fibrous character of wrought iron, however, is so deeply rooted that even many modern writers of repute still refer to that metal as being fibrous, and many qualities have been, and still are, claimed for wrought iron because of the presence of these fibres which are denied to steel owing to its crystalline character. It may be that wrought iron resists corrosion better than steel, that it is more weldable and possesses, to a greater degree, other characteristics dear to the blacksmith, but such claims cannot be based upon the fibrous character of the metal and still less, as recently attempted in print, on the presence of iron fibres each one surrounded by a thin coating of slag, a clever, but altogether visionary arrangement.

The structure of wrought iron and therefore its physical properties is affected (1) by the presence of impurities, and (2) by the treatment both mechanical and thermal to which it is subjected. The effect of these factors will be briefly considered in another article.

Blast-Furnace Top Construction.

A most interesting sketch of some modifications introduced into practice in recent years in blast furnace construction is contained in Mr. JULIAN KENNEDY'S presidential address before the Engineers' Society of Western Pennsylvania, which is published in full in the February issue of the *Proceedings* of the Society.

The development of blast furnace construction has been towards much larger sizes of furnaces and towards the use of much wider ranges of iron ore. While the ores formerly used were coarse and lumpy, now large proportions of the Mesaba range ores are also treated which are comparatively fine and dusty, and which have a tendency to cause the furnace to work irregularly and to hang and slip.

When a furnace is working normally the blast pressure drops gradually from the level of the tuyeres up to the zone of fusion, or say 6 feet, above them, where there is a rapid drop for a short distance and then a gradual drop from this point to the top of the furnace. When a furnace is hanging, especially if it stops moving for a considerable time, the stock burns out below, leaving a cavity. In the case of a furnace hanging stubbornly, the interior of the arch formed may look quite smooth, due to fusion going on at this point.

After the cavity reaches a certain size a portion of the stock is liable to drop, breaking the arch and causing the stock above to come down with a rush. At the same time the compressed air in the cavity at the bottom of the furnace is released, and goes up through the falling stock with a tremendous rush. If the top of the furnace is constructed as shown in Fig. 1, having its hopper and cone set on the brick work and held almost entirely by its own weight, this rush of gases is liable to lift the entire top up, or perhaps throw it entirely off the furnace.

It was formerly the practice to set the hopper in a base ring resting on the brick lining alone, but as the lining sometimes disintegrated and allowed the hopper to drop into the furnace, brackets were added to prevent this, as shown in Fig. 1, and later the hopper was bolted down to these brackets or to a frame of beams which took their place. To prevent the upheaval of this bell and hopper apparatus, so-called explosion doors were placed on the down-comers, and in some cases extra openings were carried out through the casings and additional relief doors were fitted to these openings.

In the case of heavy slips, where heavy pressures and large volumes of blast are used, the upward rush of the blast picks up the ore and coke and carries it up with it and hurls it out of the relief doors in great quantities, it being not unusual to see from 30 to 50 tons of ore, coke and limestone thrown out of a furnace in less than as many seconds at the same time that a vast cloud of gases and ore dust envelopes the top of the furnace, and some time these gases light as they come out, making a tremendous flame.

Mr. Julian Kennedy took up, several years ago, the problem of preventing these so-called "explosions" with resulting loss of life and other damage. The fundamental point of his solution is that we have not to do here really with an "explosion." What really happens is that it is simply the compressed air from the blast in the bottom of the furnace rushes upwards and does the damage.

By examining the construction of blast furnaces as used at that time in the United States, Mr. Kennedy was unable to find a single furnace the top of which could not be lifted by a pressure of 2½ pounds per square inch. The throwing off of the top is therefore fully accounted for by the pressure of the compressed air accumulated in the cavity below a hanging charge.

Now, it is quite clear that the ultimate pressure which can thereby be produced in the furnace as result of a slip cannot be more than the pressure in the blast main, or, in other words, the pressure which produces the damage comes entirely from the blast engine. Now, a stream cannot raise higher than its source, and if a furnace casing is made otherwise strong enough to resist this pressure it will be entirely safe to reduce the size of the outlets to such an extent as to offer a material resistance to the flow of the gases from the furnace in the event of a sudden and heavy rush of blast through the furnace.

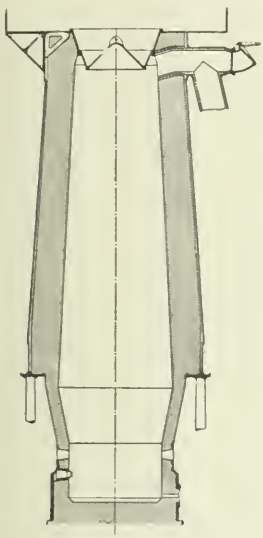


FIG. 1.—OLD CONSTRUCTION OF BLAST FURNACE TOP.

Such a checking of the gases at these outlets will greatly reduce the rapidity of flow for the moment, and will also diminish the tendency to carry solid materials out of the furnace. (In the discussion which followed the paper the following suggestive analogy was pointed out: The throttling of the gases at the outflow will reduce the amount of dust carried by them for the same reason that the waiter who pulls the cork entirely and suddenly out of the bottle will lose at least half the champagne, while the fellow who pulls it gradually will not lose a particle.)

The first furnace built on these principles of Mr. Kennedy was at the Iroquois Iron Co., in Chicago, but there are now in operation twenty-four furnaces of this general construction, and these furnaces have demonstrated, beyond a shadow of a doubt, that it is absolutely safe to altogether close the top of the blast furnace, and that the letting loose of great volumes of dust and lumps of stock at this point is entirely unnecessary.

It has been said that even if the dust is all brought down the down-comers, it will pass through the stoves and boilers, and thus be scattered over the surrounding country. Some of it, of course, will, if no arrangements are made to stop it, but a large proportion of it can be caught in very simple dust catchers, and since gas engines have been installed at furnaces, there have also been started gas washers so perfect that they will take gas from a furnace running on a mixture consisting largely of Mesaba ore and cleanse it till it has less dust in it than the ordinary atmosphere. So that given a device that brings all the gases down to the cleaning apparatus, it is entirely feasible to do away with the dust absolutely.

Mr. Kennedy concluded with the remark that there surely can be no excuse in the future for burning men on top of furnaces, or burning or otherwise injuring them with materials thrown out of the tops of furnaces because of slips, and the amount of dust sent out from a furnace will depend entirely on how perfectly the management choose to cleanse the gas by means of dust catchers and washers, which have at the present time been developed to a degree of perfection which will enable the top of a furnace draft stack to be "cleaner, as far as dust particles are concerned, than the cleanest spot in Pittsburg is at present."

Of course, all the above considerations refer only to the bad results of slips, which are falsely called explosions, and not to real explosions. They are known to have occurred in furnaces when blown out, and when nearly empty a lot of air possibly gets through the thin incandescent bed of fuel without being burned and mixed with the gases above, and then the whole business exploded. These are real explosions.

In the discussion the use of the blast furnace gases was referred to by various speakers. Mr. Kennedy referred to Sir

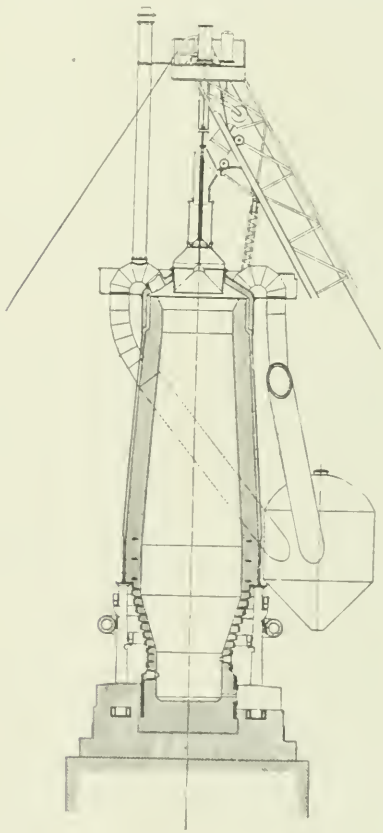


FIG. 2.—MODIFIED CONSTRUCTION OF BLAST FURNACE TOP.

William Ramsay's statement that in the future the blast furnace would be run as a gas producer and pig iron would be a by-product, and thought that this statement is perhaps not so wild as it would at first seem. He expressed his opinion that the most suitable way of utilizing the blast furnace gas is in gas engines.

For other commercial purposes the gas is probably too weak. It has not much illuminating power, and has not heating power enough to use, for example, in open-hearth furnaces.

But the gas is an ideal gas for gas engines, simply for the reason that it is not so strong as some of the other gases.

Compound Steel—A Modern Steel Plant Proposition.

By Peter Eyermann.

Open-hearth steel versus Bessemer steel—this is the great struggle between two rivals in modern steel manufacturing plants. The average user of open-hearth steel claims that this quality of steel is better than the Bessemer. The manufacturer, however, has much less trouble and costs with the latter. Therefore, it is his intention to keep the market up with Bessemer quality.

The complaint has been frequently heard that for many applications this material is less suited than that produced in the open-hearth. From a scientific standpoint it is difficult to see why the latter should be superior, since the chemical end result in both can be made entirely alike. But there is a physical explanation for this practical inequality. The blowing operation is probably too rapid to permit keeping pace with the reactions within the modern large sizes of Bessemer converters all uniformly through the entire bath of molten metal; there is also no time for thorough continuous chemical analyses. And even when the spectroscope is used for observation of the flame, one merely depends on the physical tests and senses of the assayer or men in charge.

Of course, since the general adoption of the mixer, the blowing process, for both acid and basic converters, was so far simplified that any question of a difference between Bessemer and Martin quality could have been entirely disregarded, because the composition of the charged liquid pig iron which is drawn off from the mixer is definitely determined beforehand. But the old prejudice exists yet.

In the open-hearth process, however, the mixer never played such an important part, because there was always ample time for both chemical and physical tests and observations, and the uniform quality was thus assured without resorting to the use of the expensive mixer. But also in this case it is much easier to produce the desired quality of steel by using the mixer, as the pig iron contains always an approximately uniform and even percentage of silicon, carbon, manganese and phosphorus.

At the present time, therefore, in the various methods of steel production the governing factor has come to be not so much a question of quality as one of costs and quantity. The Bessemer process is still unrivaled as regards its cheapness, and the Siemens-Martin process still unrivaled concerning quality and cheapness, the latter only in comparison with the expensive crucible steel. The average production of an open-hearth furnace is yet about 100 tons in 24 hours and 800 tons daily for the Bessemer furnace. The output of Thomas converters is generally less. It may, therefore, be safely assumed that one open-hearth is equivalent to only one-seventh of a converter in point of production, which fact affords an excellent indication of the greater capacity of the converter steel works of to-day.

Now, since human knowledge of iron ore started, since those gray historical times up to date, the idea was never dropped to make steel straight from iron ore. The readers of this journal are, of course, acquainted with this history, and it is not the purpose of these lines to repeat known things. I will mention here only the recent developments of various electrical methods—in my mind all ingenious theoretical experiments, but impractical yet.

Before going into the real subject I may call attention to the recent development of the modern gas engines driven by blast furnace gas. For many years this gas was escaping unseen by daytime, and the bright light from the furnace tops was throwing its shine into the night down on the human buildings, like light fires are guiding the ships on the ocean now. In this way uncounted millions have been and are still being lost. It is only a few years ago that even up-to-date engineers asked the question, "What has a gas engine to do with a blast furnace?" But now so much has already been written on this subject that I will note only the main points to be considered in this question.

The blast furnace of the future will be considered as a big gas producer. The gas might be used in gas engines to generate electricity for general power purposes, or it may be used in gas furnaces for the manufacture of steel or other products. There is already also some talk of the entire abandonment of the coke ovens. But as this field is not yet so far developed, I have to start with those fuel furnaces for the blast furnaces.

The following calculation is of minor influence on my compound-steel furnace, but it is a part of it, as it proves that this coke oven gas is available in sufficient quantities in modern by-product plants so as to allow its further use in steel furnaces or in gas engines. Eleven thousand tons of soft coal yield in average about 10,000 tons of dry coal, and are converted to about 7,850 tons of coke. The balance left consists generally of

110	tons	of sulphate of ammonia.
100	"	tar.
30	"	pitch.
60	"	benzol.
5	"	naphtha.
2	"	sal ammoniac.
120	"	ashes, etc.
1,600	"	coke oven gas.

Practice has proved that 1 ton of coal is equivalent to about 9,000 cubic feet or even more of such gas. The heating value is somewhat lower than that of city gas, averaging, say, 500 B. T. U. per cubic foot. A good gas engine will yield 1 hp. per hour for 10,000 B. T. U. But considering less favorable conditions, 12,000 B .T. U. may be assumed in this calculation; 24 cubic feet per hour of this gas are therefore required per horse-power.

Fifty per cent of all gas has to be taken for heating the coke ovens, and if ten further per cents are deducted for uncontrollable leakage, only 3,600 cubic feet of gas are available for power per ton of coal, or $3.600 \div 24 = 150$-hp. hours for each ton of coal charged in the coke oven.

This result can be checked in the following way: One pound of coke oven gas is equivalent to about 33 cubic feet at normal temperature; 2,000 pounds, or 1 ton of coke gas measures 66,000 cubic feet, hence the above noted 1,600 tons of coke oven gas measures 105,600,000 cubic feet of gas. Sixty per cent off for heating and loss leaves for power 42,240,000 cubic feet, yielding 1,760,000-hp. hours. The quantity of coal charged was 11,000 tons, and $1,760,000 \div 11,000$ gives 160-hp. hours per ton of coal charged.

Practical experience shows that in a blast furnace plant there are required about 8 to 10 hp. per ton of pig iron produced to run the plant. A 500-ton furnace would require, therefore, about 5,000-hp. machinery. It has already been claimed that a coke plant near the blast furnace plant is sufficient to run the latter. Is it true?

Five hundred tons of pig will require, roughly, 500 tons of coke; 1 ton coke equals 1.3 to 1.4 tons of coal. If we consider only 1.3 tons, we have $500 \times 1.3 = 650$ tons of coal charged in the coke ovens in 24 hours. Hence, $650 \times 150 = 97,500$-hp. hours will be available from the coke plant during 24 hours. This means that there are continually available $97,500 \div 24$, or approximately, 4,000 hp. If we assume a power requirement of only 8 hp. for the ton of pig iron, these 4,000 hp. cover exactly the requirements of the 500-ton furnace plant.

If I can cover, therefore, the wants of my blast furnace plant by my coke ovens, why not try to cover the requirements of my steel plant by the blast furnace plant? Is it possible?

Much has been published in recent years on the proposition to use the available blast furnace gas in gas engines, and many practical results have been obtained in Europe, and more recently also in America. I will, therefore, deal with this subject

only in so far as is necessary to find the amount of gas from the blast furnace which is used in the steel plant and will discuss how it is used in a plant.

A considerable number of furnaces are operating now with an average output of 24 tons of pig iron per hour, or 576 tons per day of 24 hours. For convenience in calculation we will use this figure.

With the object of obtaining as much gas as possible from the blast furnace, using it as a large gas producer, the pig iron can be obtained, on paper, at least, as a by-product in modern steel manufacture. Here is the proof:

With the object of obtaining somewhat richer blast furnace gas than may be obtained by using coke alone, some soft coal may be charged into the furnace with the coke. It may be preferable under certain conditions to mix coke oven gas with the blast furnace gas in order to secure a more uniform gas or to install a "mixer" also for all gases of one complete plant.

For each ton of pig iron we get 150,000 cubic feet of gas, having an average heating value of 100 B. T. U. per cubic foot. If, therefore, all gas would be transformed into power, then 150,000 × 100 = 15,000,000 B. T. U. would be at disposition for each ton of iron. The gas engine requires 12,000 B. T. U. per hour to produce 1 hp., so that 1 ton of iron per hour will yield 1,250 hp., or in a 576-ton daily plant about 30,000 hp. will be available. In the near future a good deal of the heat which is required to heat the blast may be obtained from the liquid cinder, thus doing away with the high and costly hot-blast stoves, but at present we must still consider them as follows:

Twenty-five per cent of the gas of the blast furnaces is to be deducted for heating the stoves. The plant producing 576 tons of pig iron daily, yields 3,600,000 cubic feet of gas per hour; 25 per cent of this amount, or 900,000 cubic feet, are to be set aside for heating the blast.

To supply the required amount of air in the blast furnace the blowing engines are built on an average of, say, 80 to 100 cubic feet of air per pound of coke charged in furnace. For 24 tons per hour are therefore required 2,000 × 24 × 100 = 4,800,000 cubic feet of air per hour, or 80,000 cubic feet per minute. With a pressure of up to 25 pounds per square inch, each 100 cubic feet per minute require about 4 to 5 hp. per hour; hence a furnace of 24 tons of iron per hour requires for its blowing engines from 3,200 to 4,000 hp. The modern gas blower requires 12,000 B. T. U. per horse-power-hour, or if we assume again 100 B. T. U. per cubic foot of gas, about 120 cubic feet of gas. This would result in a further deduction of 480,000 cubic fet of gas for blowing engines, but as these engines are not always running under full power, a figure of 400,000 cubic feet per hour may safely be assumed.

The uncontrollable leakage in an up-to-date plant should be not more than 5 per cent, or 3,600,000 × 0.05 = 180,000 cubic feet per hour.

Mechanically-operated gas-cleaning plants have given better results than plain washing towers; for this purpose are required from 0.4 hp. to 0.7 hp. per 1,000 cubic feet gas. If all gas is cleaned (a proposition which has to be considered in a modern plant) we get 3,600 × 0.7 = 2,520 hp., or 302,400 cubic feet of gas. Since this plant is not always running under full load, 252,000 cubic feet per hour will be a fair figure for this purpose.

For auxiliary machinery, such as ore, lime and coke-handling apparatus, electric light plant, power transmission, compressed air, oil and water pumps, elevators and hoists, pig crushers, casting machine, etc., there are required per ton of pig iron per day not more than 2 hp. per hour, or for our 576-ton daily plant a 1,152-hp. engine. Making again some allowance for times of light load, 115,200 cubic feet of gas will be required per hour for this purpose. The balance sheet for gas is therefore:

	Cubic Feet
Obtainable per hour	3,600,000
Losses, blast heating	900,000
Blowing engine	400,000
Leakage	180,000
Cleaning	252,000
Auxiliary power	115,200
Total loss	1,847,250

Hence there remain for utilization 1,752,800 cubic feet per hour.

Considering 100-B. T. U. quality, this means 175,280,000 B. T. U. per hour for further use in gas engines, which for 12,000 B. T. U. per horse-power-hour means 14,600 hp., or, in accordance with standard gas engine experience, about a 10,000-kw. plant.

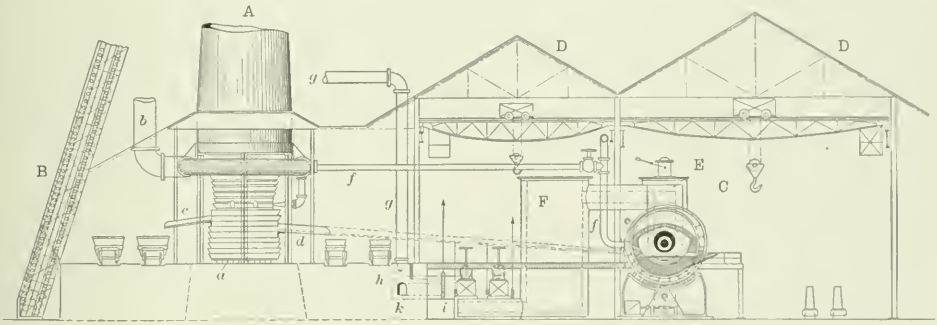


FIG. 1.—DIAGRAM OF ARRANGEMENT OF BLAST FURNACE AND STEEL PLANT.

From this we can deduce that the blast furnace as a gas producer covers the costs of manufacturing pig iron. For if we assume an exceptionally high cost for manufacturing pigs at $12.00 per ton, we have in our 576-ton daily plant an expense of $288 per hour. The 10,000 kw., however, we have in surplus, and can sell them, say, for 2½ cents or 3 cents per kw-hour to the public in form of electrical energy. This means an income of $250 to $300 per hour, thus equalizing the entire manufacturing costs.

* * * * * *

From this departure I now return to the steel subject. The main object of my proposition is a new method of manufacturing steel, and this method has the following advantages: (1) The cost of production is reduced; (2) at the same time the tonnage of the output is increased; (3) a less costly plant is required; (4) the plant is independent of the market prices of scrap; (5) less coal is used for the open hearth quality than hitherto. The writer was very much pleased to find some time ago a similar furnace proposition from another source, working in a large Southern steel plant simultaneously on the same

object. An article on this matter was published in *Stahl und Eisen*, in Germany, by Mr. Goldstein, of Monterey, Mex. I mention this here only to prove that my own standpoint is also based on good practical experience of others.

Fig. 1 shows the general arrangement of my improved steel plant directly attached and operating simultaneously with the blast furnace plant. The blast furnace A may be of any suitable type and construction. My improved type with the all-over-bosh-and-bottom-water-cooling system is shown, however. Like the skyscrapers of to-day, the entire structure rests on a grate of heavy beams *a*. The charging hoist is shown and indicated by B. The hot blast is supplied by line *b*, and the blast nozzles shown, too. Slag notch is at *c* and metal tap at *d*.

There is no mixer required, as in my mind this expensive vessel is in fact only an unwieldy adjunct, the use of which was rendered compulsory solely on account of the inefficiency of old-fashioned appliances and methods adopted to meet modern requirements. The working of my new plant will be effected without the aid of the expensive Bessemer blowing engines, such as required for the converters; a rough fining of the liquid pig iron, tapped directly into the compound steel furnace C by means of cold or hot blast from the *blast-furnace* blowing engines, may be obtained from a pipe connection *f*. Further, the expensive buildings necessary for the accommodation of the long rows of open-hearth furnaces of to-day can likewise all be dispensed with, together with the entire gas producer plants. The building D, as shown, would not take more space than that of the attached cast houses of a modern blast furnace plant.

The furnace C will cost about twice as much as a modern large stationary open-hearth and the same amount as an up-to-date "Talbot" or other big tilting furnace. E represents the apparatus for increasing the quality of the blast furnace gas to be used for heating purposes in the open-hearth. A pipe connection *g* for this purpose may branch off somewhere conveniently from the furnace gas main, and is attached at *h* to the reversing gas valve *i* of the furnace; *k* indicates the flue to any of the furnace smokestacks.

The steel furnace, called "compound furnace" hereafter, on account of the combined open-hearth process and converter method, is shown in Fig. 2 and Fig. 3. Fig. 2 is a plan view; Fig. 3 a longitudinal section, and C in Fig. 1 is a cross-section.

The inclined air—blast nozzles, acting on or in the bath of the metal, are shown in C and in Figs. 2 and 3 as well. The

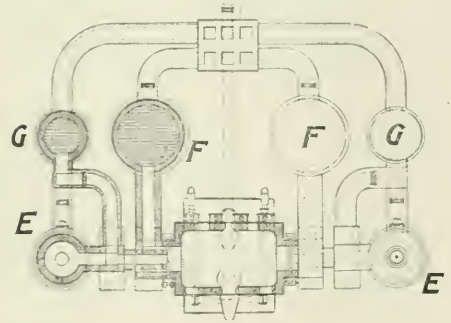


FIG. 2.—PLAN VIEW OF COMPOUND FURNACE.

"improving towers" for gas are E throughout; the gas regenerators, in this case better called "reheaters," are shown at G, and the reheaters for air at F.

As the usual furnaces are too well known to the readers of this journal I will not waste space and time in further description, but will shortly finish the main object, namely, the proof that blast furnace gas can be used in open-hearths, and that there is enough in surplus to run the steel plant when "compound steel" is manufactured.

I refer here to an invention of Mr. Ehrenwerth as long ago as 1883, which relates to the regeneration of blast furnace gas.

In von Ehrenwerth's calculations the absolute calorific value of blast furnace gas of poor quality is given as about 705 Calories per cubic meter, or about 80 B. T. U. per cubic foot.

This gas had a composition of

	Per Cent.
Carbonic oxide	24.23
Carbonic anhydride	20.60
Hydrocarbons	0.38
Hydrogen	0.21
Nitrogen	54.58
	100.00

If this gas were perfectly regenerated it would contain

	Per Cent.
Carbonic oxide	43.42
Carbonic anhydride	0.00
Hydrocarbons	0.21
Hydrogen	0.15
Nitrogen	57.52
	100.00

And its absolute calorific value would be increased to about 120 B. T. U. per cubic foot.

Some time later other authors also made experiments, and

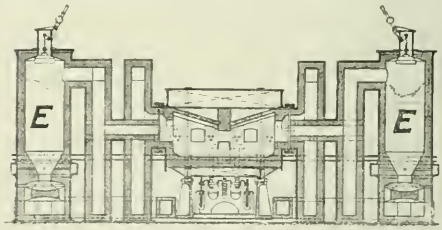


FIG. 3.—VERTICAL SECTION OF COMPOUND FURNACE.

found that blast furnace gas of about 932 Calories would give a suitable furnace heating gas of up to 1,472 Calories, or of a heating value of 160 B. T. U. per cubic foot, better than any standard gas producer gas. Since modern gas engines can also successfully be operated on the *raw* gas and since ore-roasting furnaces, lime-burning cupolas, etc., have also been successfully operated on this raw gas, therefore there is no doubt at all that even high heats as required in melting furnaces can be obtained from blast furnace gas.

In general, an open-hearth furnace of, say, 50 tons capacity, will use about 800 pounds of coal per ton of the product. The output per day is about 100 tons steel, which require, therefore, 80,000 pounds of coal to be gasified in the gas producers in 24 hours, or 3,333 pounds of coal per hour.

One pound of coal yields about 75 cubic feet of producer gas. Hence in our plant we have about 250,000 cubic feet of gas per hour, with an average heating value of approximately 130 B. T. U. One hundred tons of steel require, therefore, $80{,}000 \times 75 \times 130 = 780{,}000{,}000$ B. T. U., or 1 ton, requires 7,800,000 B. T. U. for manufacture.

My intention is now to convert the 576 tons of pig iron in the *same* time in which they are produced into steel of open-hearth quality in a single furnace. If we assume a tap in each 4 hours, 96 tons are tapped six times in a day of 24 hours. Four hours are sufficient to transform this iron into steel, after a preliminary rough fining of the metal by means of the hot blast, besides a modern, say, Talbot continuous process, even if iron ore in lieu of scrap is to be used to a considerable extent. The latter method, however, will turn out profitably only with the high scrap prices of to-day. This all considered,

the 576 tons pig iron will yield in a continuous process about 600 tons of steel in 24 hours, or 25 tons per hour. Each ton requires, as shown before, 7,800,000 B. T. U., so that 195,000,000 B. T. U. per hour are required for 25 tons per hour.

As formerly shown in this article, there are about 175,280,000 B. T. U. for further use left per hour from the blast furnace plant, if we do not take into consideration the improvement of the gas by regeneration. The latter will practically amount to, say, only 20 per cent in heating value; the theoretical result gives 30 and 40 per cent. If we add 20 per cent to above 175,000,000 B. T. U., the available total from the blast furnace gas is increased to 210,000,000 B. T. U.

We have, therefore, a surplus of 15,000,000 B. T. U. over the required 195,000,000 B. T. U. per hour, so that the "regenerators" do not need to be continuously in operation. The coke required to perform this chemical improvement of the gas is easily obtained without cost from the waste of the coke-oven braize and the waste of small coke from the blast furnace plant.

The calculations prove, therefore, that this new process for manufacturing "compound steel" could be worked with blast furnace gas in a rational manner, since the expenditure in gaseous fuel practically falls considerably below that of the equivalent amount of solid fuel.

Any discussion of this subject and any criticism will be very much appreciated by the author of these lines, and any proof of an error in one of the facts or opinions given above will be noted with thanks in the interest of modern progressive work.

Dubois, Pa.

The Osmotic Pressure before the Faraday Society

At the twenty-sixth ordinary meeting of the Faraday Society, held in London on Jan. 29, 1907, Prof. H. E. Armstrong being in the chair, a general discussion on *osmotic pressure* took place. The discussion was opened by the Earl of Berkeley, who exhibited and described his apparatus for the direct measurement of osmotic pressure.

The ordinary direct method of measuring osmotic pressures is to obtain equilibrium on the two sides of the semi-permeable membrane by means of the pressure of a head of liquid. The method devised by the author and Mr. E. G. J. Hartley substitutes mechanical pressure, which is put straight on to the solution and equilibrium thus obtained. Reversing the usual arrangement, the solution is put outside the semi-permeable tube, in an outer containing tube of gun-metal, and the solvent inside, suitable mechanical arrangements being provided for rendering the joints leak-tight. The pressure is obtained from a plunger worked with a pile of weights and delivered through a mercury U-tube to the solution outside the septum. Equilibrium is obtained or calculated by watching through a telescope the motion of the solution in a gauge. The measurements may be made at any desired temperature. Corrections are applied for the imperfect semi-permeability of the membrane by analyzing the solvent to see if any solution has passed into it.

A vapor-pressure method for measuring osmotic pressure was also described. This is a modification of the Ostwald and Walker dynamical method. Air is sucked through a spiral train of glass vessels containing first sulphuric acid, to dry it, then the solution from which it gets saturated up to the vapor pressure of the latter, then the solvent, of which it here takes up more, and finally sulphuric acid again. There are two trains of vessels arranged to oscillate about a central axis, so that the air does not actually bubble *through* the liquid, which is unsatisfactory, but merely passes *over* them, glass beads being placed in the tubes to increase the melting surfaces. The whole apparatus can be placed in a bath and worked at any desired temperature. Arrhennius' relation was used for calculating the osmotic pressures from the lowered vapor pressures, and very concordant results were shown to have been obtained between measurements made by the direct-pressure and the vapor-pressure methods. The author is of opinion that the latter method will chiefly have to be relied upon to furnish accurate data for the further study of osmotics.

Mr. W. C. Dampier Whetham, F. R. S., speaking on "Indirect Methods of Measuring Osmotic Pressure," agreed as to the importance of the vapor-pressure method. He discussed the formula used by Berkeley and Hartley, and explained the difference between it and the van't Hoff formula obtained from thermodynamic considerations, the expressions being identical where there is no change of volume of the solvent as it enters the solution.

Dr. T. M. Lowry spoke on "Osmotic Pressure from the Standpoint of the Kinetic Theory." The motion of the particles postulated by the kinetic theory leads in the case of composite gases or liquids to a process of diffusion. When diffusion is resisted a pressure is set up which constitutes the osmotic pressure of the system. This can be effected by means of a semi-permeable membrane, through which only one of the constituents can pass. Such membranes undoubtedly act in virtue of their solvent properties.

The application of the equation $PV = RT$ to the osmotic pressure of gases could be predicted on general theoretical grounds, but there was no *a priori* reason for supposing that it would be applicable to the case of liquids. The mere fact that all liquids were not miscible was sufficient to show that the conditions were widely different from those prevailing in mixed gases. The validity of the law had been established experimentally, and must be accepted as a fact of fundamental importance in all discussions as to the nature of osmotic pressure.

In the early years of the osmotic discussion it had been assumed by van't Hoff and others that since osmotic pressures and gas pressures could be calculated by means of the same formula the conditions must be identical in the two cases, and it was definitely stated that in dilute sugar solutions the osmotic pressure was wholly due to the bombardment of the membrane by the molecules of the sugar, the effects produced by the water molecules being substantially identical on either side of the membrane. The alternative view, that osmotic pressure represented a diminution in the activity or "active mass" of the solvent was suggested by Poynting in 1896, and had subsequently been advocated by Armstrong, Beilby, van Laar and others. In most cases it had been assumed that the essential factor was a diminution in the average energy of the water molecules. From the standpoint of the kinetic theory this was unnecessary, as also was the view advocated by Rodger and by Traube that the solute was directly combined with one or more molecules of the solvent. The mere presence in the surface of the solution of molecules of the solute which could not enter the membrane was sufficient to check the escape of solvent particles from the solution into the membrane, without affecting the reverse passage of solvent from the membrane into the solution. This would lead to a diminished solubility on the side of the solution and to a flow of liquid through the membrane which could only be checked by putting pressure on the solution.

The simplest case of a semi-permeable membrane is undoubtedly to be found in the surface of separation between liquid and vapor. At such a surface the kinetic theory postulates a continual interchange of molecules between the two phases. But while the rate of escape or evaporation would be reduced by the presence of non-volatile molecules in the surface, the rate of condensation would be unaffected, and equilibrium could only be restored by decreasing the vapor pressure and so diminishing the rate of condensation at the surface of the solution. In this case a quantitative relationship could be deduced. If N and n were the relative numbers of particles of solvent and solute in the surface and p and p' the vapor pressures of solvent and solution, then if each molecule of solute replaced a single molecule of solvent in the

surface layer, the reduction of vapor pressure would be shown by the equation $\frac{p'}{p} = \frac{N}{N+n}$. It had been shown by Nernst that from this simple relationship the identity of the osmotic pressure of a dilute solution with the pressure exerted by a gas of equal molecular concentration could be directly deduced. The blocking of the surface was, therefore, sufficient to afford, not merely a qualitative, but also a quantitative explanation of osmotic pressure.

The further discussion of the surface structure of liquids as related to the osmotic phenomena will be printed in the *Transactions*.

Prof. L. Kahlenberg sent in a communication to the discussion on "The Bearing of Actual Osmotic Experiments Upon the Conception of the Nature of Solutions." The occurrence of osmosis and its direction and extent are determined by the nature of the septum and of the liquids that bathe it. Experiments have shown, too, that there is always a major and minor current present, following in opposite directions, although it often appears as if the osmotic process were one-sided. In this case the septum is termed "semi-permeable," and recent research has centered around so-called semi-permeable membranes which really do not exist. The author has demonstrated that it is peculiarly strong selective action on the part of the septum which causes it to be approximately semi-permeable in certain cases, and he has recently even succeeded in separating two colloidal substances by dialysis. This selective action is due to the solubility or insolubility of the substances concerned in the membrane, and therefore osmotic pressure is due to the same forces—essentially chemical in character in the opinion of the author—as the process of solution, and they may be quite variable as different septa and different liquids are employed. The usually accepted "sieve theory" is untenable, because larger molecules frequently go through a membrane more readily than smaller molecules.

So-called semi-permeable membranes have of late years been studied on account of their bearing on van't Hoff's "gaseous pressure" theory of solution and of osmotic pressure. This maintains that as long as the membrane is semi-permeable the osmotic pressure is the same in the case of any septum for a given solution against the pure solvent, a position contrary to experimental facts.

Again, by applying Carnot's cycle and the usual thermodynamic formulæ to the hypothetical case of abstracting, and then returning solvent from a dilute solution in a cylinder fitted with a semi-permeable piston, relations have been deduced between latent heats of fusion and freezing points, and latent heats of vaporization and boiling points, assuming the gas equation to hold for dilute solutions. But the results obtained are frequently far from the experimental values found for different solutes in the case of one and the same solvent (in the case of electrolytes), and it has been necessary to postulate either dissociation or polymerization; but the author, referring to his previous papers, considers these explanations are weak and unnecessary. The thermodynamic calculations involve the assumption of a semi-permeable membrane which at the same time is quite passive. As it is selective action which produces semi-permeability, no such membrane can exist. Therefore, thermodynamic osmotic pressure (which is not really osmotic pressure at all) is quite a different thing from that measured by experiment. Finally, to speak of the experimental osmotic pressure of any solution, without mentioning what septum is used to separate that solution from what other liquid, is devoid of meaning.

Mr. H. N. Morse communicated tables containing a summary of the recent experiments, the results of which are about to be published, made by him and Mr. Frazer, with glucose and cane-sugar. The conclusions arrived at are: (1) In the vicinity of 20° the osmotic pressure exerted by either is equal to that which a molecular equivalent quantity of a gas would exert if its volume were reduced, at the same temperature, to the volume of the solvent in the pure state. (2) Between 18° and 26°, at which the measurements were made, both cane-sugar and glucose in solution are in the anhydrous condition. Measurements made just above 0° yield pressures somewhat above the calculated gas pressures. Measurements with electrolytes are about to be made in which osmotic pressure and dissociation will be determined simultaneously.

Dr. J. C. Philip thought, with reference to Dr. Lowry's hypothesis, that whatever views might be entertained as to the nature of osmotic pressure, one was bound, on thermodynamic grounds, to conclude that dilute solution must behave as a gas in relation to concentration and temperature.

Mr. J. G. A. Rhodin remarked on the fact that osmotic pressure as usually explained seemed to work in the wrong direction, namely, from the lower in the direction of the higher pressure. It was remarkable, too, that a semi-permeable membrane should conduct electricity so easily. Many of the supposed agreements between calculated and observed results and modern physical chemistry were due to a reckless and unjustifiable use of the method of least squares.

Dr. Alexander Findlay said that on account of unfamiliarity with van't Hoff's theory of solutions there had been much misunderstanding as to what was the problem actually to be investigated. Referring to Kahlenberg's objection to semi-permeable membranes, from the thermodynamic standpoint it did not matter whether there were selective absorption or not, provided the changes in energy were equal in opposite directions. He considered that the quantitative side and the thermodynamic side of the subject had been thoroughly worked out, and the remarkable accuracy of the work of Morse and Frazer, and Berkeley and Hartley, pointed to absolute agreement between experiment and the van't Hoff thermodynamic theory. He did not take kindly to Dr. Lowry's kinetic explanations, and thought that the membrane might be left out altogether, and the diffusion only between a solution and a layer of pure solvent on the top of it made use of for explaining what took place.

Mr. W. A. Davis said that van't Hoff's original hypothesis neglected the influence exerted on the solute by the solvent; Dr. Lowry's modification of van't Hoff's conception was therefore necessary from that standpoint. Osmotic pressure had also been explained as the tendency to equalize the surface tension on the two sides of the osmotic cell.

The Earl of Berkeley disagreed with Dr. Findlay that the thermodynamic was the only logical way of looking at things. He discussed further the discrepancy between the formula used by him and the thermodynamic formula which could be explained on the conception one formed of osmotic pressure.

Dr. T. M. Lowry said that the views he advocated accounted for the negative direction of the osmotic flow referred to by Mr. Rhodin. It was not remarkable that Boyle's law should hold good for osmotic pressure, but it was remarkable that the constant R in the two cases should be identical. The agreement should throw light on the surface structure of liquids.

Prof. H. E. Armstrong, the chairman, emphasized the general applicability of the vapor-pressure method, which, although tedious and troublesome, could be used with any solvent, at all temperatures, and under all pressures. The compressibility of liquids would prevent it agreeing quite with direct measurements; it was therefore important that careful comparisons of the two should be made. In reply to Dr. Findlay, Morse and Frazer's results did not agree with those of Berkeley and Hartley; there was a possible constant error in the former, in spite of the extraordinary accuracy of the work. He hoped more experimental work would be done with living tissues on the line of Pfeffer's original measurements. The term "osmotic pressure," unless merely used in the sense of a pressure required to establish equilibrium, was a misleading one; there was nothing to show that a pressure existed inside a solution in a closed vessel apart from simple gravity pressure. The

results of Morse and Frazer brought dilute and concentrated solution into line, and were a great advance on the van't Hoff treatment; they put the ordinary gas point of view quite out of court. He depreciated the dogmatic, unscientific treatment to which the whole subject had been subjected for the purpose of bolstering up a particular point of view: the facts needed examination from a broad and critical standpoint.

The authors reserved their full replies for the printed discussion in the *Transactions*.

Professor Henri Moissan.

Two Obituaries.

I.

Science has been cruelly robbed of one of her most brilliant and indefatigable workers, in the death of M. Henri Moissan, which occurred at Paris, on Wednesday, Feb. 20, after an operation for appendicitis.

Although Henri Moissan has for long been known throughout the whole world as one of the foremost chemists of the age, many have misunderstood the nature of the claims upon which his fame is founded. It may, therefore, be of some interest to emphasize certain leading traits of his character and recall some of the numerous brilliant researches which have been carried out in his laboratory.

Henri Moissan

In the first place, it is necessary to remember that Moissan's early work as a student was carried out under the guidance of Henri Sainte Claire Deville and Debray, and that his whole life work worthily upholds the traditions and high quality of that brilliant French School of "Chimie Minérale," led by Deville, and which has, throughout, been noteworthy for genius and resource in experimentation.

Henri Moissan was born on Sept. 28, 1852, in Paris, and at an early age developed an interest in chemistry.

His first research, published in 1877, on the oxides of the iron group was amplified and presented in 1880 as a thesis for the doctorate of science in the "Faculté des Sciences" at Paris.

Up to this time Moissan held various minor posts at the Natural History Museum and elsewhere, but most of his energy seems to have been devoted to his research work. In 1886, soon after his isolation of fluorine, he was elected professor of toxicology in the "école superieure de Pharmacie," as it was desired to retain him in Paris and this was the only post of a chemical nature available at that time. Only in 1899 did Moissan give his first course of chemistry lectures, being appointed professor of inorganic chemistry at the same institution. Finally, in 1901, he was elected professor at the Sorbonne to fill the most important chair of chemistry in Paris. In 1891 he was elected a member of the Academy of Sciences, the crowning honor of a French scientific man.

Although a Parisian by birth and residing all his life in this, the gayest capital of Europe, Moissan never took any considerable part in social or political affairs. He was of a retiring disposition and was intensely devoted to his science; he has himself clearly expressed the determined way in which he cultivated the "simple life": "Ma vie a eu toute la simplicité de ma carrière de professeur et mon existence s'est partagé heureuse jusqu'ici entre mon laboratoire et ma maison."

Even during the long tenure of his professorship of toxicology, Moissan maintained a research laboratory and attracted to it a number of chemists, some even from distant countries. His pupils have one and all carried away an affectionate remembrance of his interest and encouragement in their work. As a lecturer, particularly in his public discourses and in the excellent courses on inorganic chemistry which he gave in the last few years of his life, Moissan was distinguished even amongst French chemists by his brilliant oratory and his skill in experimental demonstration.

As a scientific worker, Moissan's fame rests on two great researches; in the first, he overcame the difficulties which had baffled the experimental skill of Sir Humphrey Davy, Faraday, Frémy and a host of other workers, and at last isolated the element fluorine; in the second, he first showed how the electric arc might be utilized as a valuable instrument for chemical research and prepared many hitherto rare and refractory elements and several series of new compounds of great interest in chemical science.

On June 28, 1886, Moissan communicated to the Academy of Sciences the first details of his work on the preparation of fluorine by the electrolysis of anhydrous hydrofluoric acid, and in the following month gave a more complete account, which enabled the importance of his work to be realized. The success thus achieved was in no way due to chance; the record of the work indicated the logical trial, abandonment and improvement of a number of other likely methods of preparation. The difficulties were well known to all chemists, since for more than seventy-five years memorable attempts had been made to isolate this, the last of the unliberated elements. That the work was not without danger may also be gathered from the fact that at least two professors of chemistry had succumbed to the poisonous and corrosive effect of the vapors of anhydrous hydrofluoric acid. His reputation as an experimental chemist of the first rank was soundly established so soon as the truth of his results were proved. But for some years other experimenters, not succeeding in repeating Moissan's work, questioned the accuracy of his results. In 1893 the question had been so debated in England that Moissan sent over his chief assistant, M. Meslans, to demonstrate the isolation of fluorine before the British Association at Nottingham.

The main reason which impelled him to pass from the fluorine investigations to the study of chemical reactions occurring at high temperatures seems to be closely connected with a desire, which he had long entertained, to solve the mystery of the origin of the diamond. The hope that the great affinity of fluorine for other elements would help him in his quest was not realized. He was, however, led to a methodical study of the behavior and transformation of the three allotropic modifications of the element carbon-diamond, graphite and charcoal. From a study of the diamond as it occurs in nature he came to the conclusion that immense pressure was the determining factor in its production. A proof of this seemed to be supplied to him by a meteorite from the Diablo Canon, which, in the middle of a mass of iron, revealed two small transparent diamonds, surrounded by amorphous carbon in compressed strips. "Nature," he says, "seems to have been caught in the act."

How he planned and successfully carried through the adaptation of this idea in the laboratory with the successful production of minute diamonds is well known to all.

It was for the purpose of augmenting the quantity of carbon dissolved in iron that Moissan first required and adopted the electric furnace.

In his electric furnace work Moissan's pre-eminent position is due, not to the design or discovery of a special form of furnace, but rather to the skill with which he investigated in detail a number of individual chemical reactions. In each case he devoted great care to the purification and analysis of the raw materials required in the process, and submitted the products to careful examination and quantitatively determined their composition. Thus his preparation of chromium, tungsten, molybdenum, uranium, vanadium and many other metals in a fused and coherent form greatly enriched our knowledge of the chemical and physical properties of these elements.

Of still greater importance was the methodical following up of the chance formation of calcium carbide which he observed around the carbon electrodes in his early furnace experiments. From this observation he was led to discover, and fully determine the nature and properties of, a large number of metallic carbides, borides and silicides, many of them hitherto absolutely unknown, or like the metals mentioned above, only obtainable in impure and fragmentary specimens handed down from one professor of chemistry to another as an heirloom of priceless value. There is, perhaps, no need to consider at the present time in how far industry is directly indebted to Moissan's work. He himself had invariably expressed his desire not to be considered in such discussions, and so far as the merit of his work is concerned it needs no support of this nature. Indirectly both industry and science have benefited enormously.

On the Continent of Europe his scientific investigations are directly credited with a renaissance in the field of inorganic chemistry, which, particularly in Germany, had been almost entirely neglected for the more remunerative field of organic chemical research. Even in England and America where the study of inorganic chemistry has always been pursued with activity, this work has been of no little assistance in instilling enthusiasm and encouraging the deeper study of such problems.

In recent years the scientific work which Moissan had carried out was still directed along the two main lines of his activity; by consolidating and extending his earlier work upon the properties of fluorine and its compounds, on the one hand, and the various physical and chemical phenomena associated with the intensely high temperature of the electric arc on the other, he has largely increased the debt which science owes to his labors. Henri Moissan is deeply mourned by many friends and admirers, who, only in December last, welcomed the well-merited bestowal of the Nobel prize, in recognition of his work, and themselves were just on the point of presenting him with a medal to commemorate the twentieth anniversary of his work on fluorine.

May his memory long remain with us and in the hands of his many admirers, lead to the continuity of the work to which he was so greatly devoted.

R. S. Hutton.

Manchester, England.

* * *

II *

"But what I cannot put into these successive chapters is the joy I experienced in pursuing these discoveries. To walk in a newly turned furrow, to feel one's self untrammeled, to see new subjects for study spring up on all sides, is so delightful that it cannot be fully comprehended except by those who have experienced the ardent pleasure of research."

With this closing to a preface, Moissan throws open the door and invites us to participate with him in the discoveries made with the electric furnace. This most skillful of experimenters, having won his spurs in the conflict of isolating fluorine, thus distancing all others who had attempted the task, he attacks new problems with zeal and the ability of an accomplished craftsman. He was truly the embodiment of Davy's adage, "It is the duty of the chemist to be bold in pursuit."

Almost his last words as he left this city in 1904 was the terse sentence, "Chemistry is still an experimental science."

Moissan's indefatigable pursuit of a problem is typically exemplified in a remark in his monograph on "Fluorine and its Compounds": "And so after three years of research I got to the first important experiment in the isolation of fluorine."

Another instance of his indomitable persistence will be remembered by some who were fortunate enough to hear his brilliant lecture, delivered at the College of Physicians and Surgeons, in 1896, when, at the invitation of the New York Academy of Sciences, the American Chemical Society, the American Institute of Electrical Engineers, and the College of Pharmacy, he demonstrated the use of his electric furnace, and showed his method of making diamonds. As he removed the glowing crucible from within the furnace and plunged it into a mass of water, some of his audience, all scientists, involuntarily moved as if expecting an explosion. "Have no fear," said he, "I have performed this experiment without accident over three hundred times."

In friendly appreciation of the honors done him on that visit to the United States, he sent to the National Museum a collection of sixteen specimens of the products he had obtained by the use of this new instrument of research. The bottles were neatly closed with parchment, and on each he had placed his signature. This collection will now be a unique record of his genius. During the same visit Moissan lectured at the Chicago University, and attended the Sesqui-Centennial Celebration at Princeton. He made a study of our educational institutions, and on his return wrote a report, in which he dilated on the advantages our country was deriving from the liberality of her citizens towards the institutions of learning, and he exerted all his influence, which constantly increased, to bring about the same state of affairs in France, where, because of the University belonging to the State, endowments were rarely forthcoming.

In 1889 he published some new researches on the "Isolation of Fluorine," and in 1890 he wrote on the "Fluoride of Carbon." He received the "Prix Lacaze" in 1887.

His work on the fluoride of carbon led to his undertaking a study of all three forms of carbon, amorphous, graphite and diamond, and it was the object of subjecting carbon to excessively high temperatures that he devised his electric furnace, a simple yet all powerful instrument. With it he undertook a long series of researches on the elements and some of their compounds, the story of which would not only take us through many a chapter of science but also unfold the beginnings of a new art in chemistry. Later, together with Dewar, he liquefied fluorine, and showed how it would combine spontaneously with hydrogen, thus establishing, at least so far, the lowest temperature at which chemical union takes place.

With this electric furnace he has demonstrated not only the indestructibility of many of the elements by the highest heat yet attained, for in a brilliant discourse given at Rome in 1906, at the International Congress of Applied Chemistry, he detailed his distillation of gold, the platinum metals, chromium, iron, nickel, manganese, tungsten, molybdenum and uranium, and before he had also demonstrated in the preparation of titanium carbide and other compounds that chemical combination took place at the highest temperatures at our command. What a technique! It is as if some master of the piano began at the bass notes and swept up majestically to the highest treble.

Moissan studied particularly the chemistry of the elements. His isolation of calcium is a further example of new methods of attacking his favorite problem. At the International Con-

* Address before the New York section of the American Chemical Society.

gress at Berlin he gave a lecture which charmed his audience and elicited the highest admiration. He presented his results on the hydrides of the alkalies and the alkali-earth metals. He added with these a further demonstration that hydrogen is not a metal, by showing that potassium and sodium hydrides, KH and NaH, do not conduct electricity, and are therefore not alloys.

We find him passing readily from the realm of inorganic to that of organic chemistry, producing potassium formiate, HCOOK, by the direct union of KH and CO_2. One can never read many pages of his memoirs without being struck with the fact that he made no sharp lines of demarcation between the inorganic and the organic; to him they were but one chemistry.

With a host of collaborators, Moissan was engaged to the last on a great work—"Chimie Minerale." A discourse given at the Convocation of Scientists at the St. Louis Exhibition in 1904, delivered at the invitation of the Government, was a resumé of his introduction of this important treatise.

During the last few years Moissan had forged ahead. He was the president of the International Congress of Applied Chemistry in Paris in 1900. He had previously been appointed to Friedel's Professorship at the Sorbonne, and with highest inspiration he was devoting his irrepressible energies to many problems. These were, indeed, multitudinous. His strictly scientific work was always paralleled with important applications for the well being of the human race. His originality showed him as a leader of thought and also a worker for his fellow beings, inaugurating new industries, planning new manufactures. Few chemists have had wider influence. A medal struck in honor of the twentieth anniversary of the isolation of fluorine was only recently given by his students and friends.

The recognition of all this was freely given to him, not only at home, for France is loyal to her sons, but also abroad. The last highest honor conferred on him was the Noble prize for chemistry in 1906.

But to those who came within the subtle influence of his personality the fact that an operation for appendicitis, which resulted fatally on Feb. 20, 1907, has severed a friendship with one whose charm of manner endeared him to students, associates and friends alike, has come as a blow so sudden and unexpected that it is difficult to fully realize it. Our sympathy goes out to his noble wife, that faithful amanuensis, who has indefatigably taken down the thoughts of the adored husband and preserved them for us, and to the young man, his only child, who is devoting himself to the same profession.

New York City. Charles A. Doremus.

Iron and Steel Statistics.

The following statistics of iron and steel production in 1906 have been returned:

United States.

The regular official statistics of the American Iron and Steel Association show pig iron at 25,307,191 gross tons, a fresh record, supplanting that made in 1905, 22,992,380 gross tons. Bessemer steel ingots and castings, 12,275,253 gross tons, against the record of 10,941,375 gross tons in 1905. Bessemer steel rails, by the makers of Bessemer steel ingots, 3,705,642 gross tons, against 3,135,729 gross tons in 1905, both records. The complete rail statistics will include the small tonnage of Bessemer steel rails (chiefly light rails) made by mills which do not produce Bessemer steel ingots, also iron rails and open-hearth steel rails.

Canada.

Pig iron, 541,957 gross tons, against 468,003 gross tons in 1905; both records; authority, American Iron and Steel Association.

Great Britain.

Pig iron, 10,149,388 gross tons, against 9,592,737 gross tons in 1905; both records; authority, British Iron Trade Association; the statistics of the home office appear later; as a rule, the two sets of statistics agree closely and are equally authoritative.

Germany.

The statistical department of the German Association of Iron and Steel Producers reports the production of pig iron at 12,478,068 metric tons (equal to 12,280,877 gross tons), against 10,987,623 metric tons in 1905; both records.

United States Steel Corporation.

Blast furnace products, including pig iron, ferromanganese, spiegeleisen and ferrosilicon, 11,267,377 gross tons, against 10,172,148 gross tons in 1905. Bessemer and open-hearth steel ingots, 13,511,149 gross tons, against 11,995,239 gross tons in 1905. All steel products for sale, 10,578,433 gross tons, against 9,226,386 gross tons in 1905.

Lake Superior Iron Ore Shipments.

Lake Superior iron ore shipments, 38,522,139 gross tons, against 34,353,456 gross tons in 1905, both records.

World's Pig Iron Production.

The statistics of pig iron production in the United States, Canada, Great Britain and Germany, already noted, make a total of 48,279,413 gross tons, against 43,867,099 gross tons by the same countries in 1905. Allowing an increase of about a million tons by the other producing countries would indicate a grand total for the world in 1906 of about 59,000,000 gross tons.

Metallurgical Calculations.

By J. W. Richards, Ph. D.

Professor of Metallurgy in Lehigh University.

Problem 70.

In the open-hearth furnace of Problem 69 (this journal, March, 1907, p. 81) the calculations therein made showed that, per heat of steel produced, 5,191 kilograms, there entered and left the furnace the following volumes of gases, measured at standard conditions:

	Producer Gas.	Air.	Chimney Gases.
CO^2	235 m^3	....	1,830 m^3
O^2	60 m^3	3,833 m^3	1,116 m^3
CO	1,467 m^3	....	....
CH^4	26 m^3	....	....
H^2	539 m^3	....	....
N^2	3,833 m^3	9,679 m^3	13,512 m^3
H^2O	726 m^3	211 m^3	1,500 m^3

The temperature of air used was 26°, of producer gas 165°, of chimney gases 400°. The excess of air used was 48.5 per cent. The gas and air entered the laboratory of the furnace preheated to 1,100°, and the products of combustion entered the regenerators at 1,450°. Items of heat balance sheet:

Available.

	Calories.
In warm charges	189,210
Sensible heat of air used at 26°	90,480
Sensible heat of gas used at 165°	360,550
Heat of combustion of the gas	6,202,300
Heat of oxidation of the bath	833,600
Heat of formation of slag	24,200
	7,700,340

Distribution

In melted steel at tapping at 1,410°	1,437,900
In slag at tapping at 1,410°	238,000
Decomposition of limestone	9,200
Sensible heat in chimney gases at 400°	3,065,350

Other losses, not classified. . .	2,949,890
	7,700,340

Required.

(1) The thermal efficiency of the regenerators.

(2) The thermal efficiency of the laboratory of the furnace.

(3) The temperature of the flame.

(4) The change in (3) if only the theoretical amount of air for combustion were used.

Solution.

(1) The products of combustion, entering the regenerators at 1,450°, carry into them the following amounts of heat:

		Calories.
CO^2	1,830 × 0.689 =	1,261
$O^2 + N^2$	14,028 × 0.342 =	5,003
H^2O	1,500 × 0.557 =	836
Calorific capacity per 1°	=	7,100

Calorific capacity per 1,450° = 10,295,000 Calories.

The same gases entering the chimney flue at 400° carry with them the following amounts:

		Calories.
CO^2	1,830 × 0.458 =	838.1
$O^2 + N^2$	14,628 × 0.314 =	4,593.2
H^2O	1,500 × 0.400 =	600.0
Calorific capacity per 1°	=	6,031.3

Calorific capacity per 400° = 2,412,500 Calories.

The gas used for combustion, entering the regenerators at 165° and leaving it at 1,100°, carried into the regenerators 360,550 Calories, as already given in the balance sheet, and carried out at 1,100° the following:

		Calories.
CO^2	235 × 0.612 =	143.8
CH^4	26 × 0.620 =	....
O^2, N^2, H^2, CO	5,899 × 0.333 =	1,964.4
H^2O	726 × 0.505 =	366.6
Calorific capacity per 1°	=	2,474.8

Calorific capacity per 1,100° = 2,722,300 Calories.

Heat abstracted from regenerators:

2,722,300 — 360,550 = 2,361,750 Calories.

The air used, entering the regenerators at 26°, carries in as sensible heat 90,480 Calories, as already given in the balance sheet, and issuing from them at 1,100° carries out the following:

		Calories.
$O^2 + N^2$	13,512 × 0.333 =	4,499.5
H^2O	211 × 0.405 =	85.5
Calorific capacity per 1°	=	4,585.0

Calorific capacity per 1,100° = 5,043,500 Calories.

Heat abstracted from regenerators:

5,043,500 — 90,500 = 4,953,000 Calories.

The thermal efficiency of the regenerators may now be calculated from three standpoints. There is no doubt that the gas and air take from the regenerators, and return to the body of the furnace 2,361,750 + 4,953,000 = 7,314,750 Calories. This is, therefore, the usefully-returned heat, and the ratio of this to the heat received by the regenerators measures their efficiency *qua* regenerators. The three figures obtained for this efficiency depend on what is to be considered as the heat chargeable against the regenerators. Are they to be charged with all the heat in the hot products at 1,450° (10,295,000 Calories), or only with the heat left in the regenerators by these products, leaving at 400° (10,295,00 — 2,412,500 = 7,882,500 Calories), or perhaps only with the heat carried in less a certain assumed amount representing the minimum temperature to which it is desirable to cool the products before they enter the chimney?

If we charge the regenerators with all the heat *brought in* by the products their thermal efficiency figures out:

$$\frac{7,314,750}{10,295,000} = 0.71 = 71 \text{ per cent.} \qquad (1)$$

If we charge them with the heat *left in* the regenerators, by the products, their efficiency is:

$$\frac{7,314,750}{7,882,500} = 0.93 = 93 \text{ per cent.} \qquad (1)$$

leaving 7 per cent of the heat chargeable against them lost by radiation from their walls and conduction to the ground.

If we think that the first calculation gives too low an efficiency, because the gases must leave the regenerators hot, in order to be used for chimney draft, and therefore some or all of the heat in the chimney gases should not be charged against the regenerators, on the other hand, the second calculation may represent too high an efficiency, because the gases may be discarded to the chimney at a higher temperature than is necessary to provide the requisite chimney draft, and this *excess* of chimney temperature and consequent heat loss is a defect of the regenerators which they should be charged with. If we assume that a chimney gives very nearly its maximum drawing capacity with the gases entering it at 300°, it would be perfectly proper to charge the regenerators with all the heat which could be given out by the products in cooling from 1,450° to 300°, heat which they should have entirely absorbed. In the case in hand, the products at 300° would contain (by calculations similar to those already made) 1,777,400 Calories, leaving 10,295,000 — 1,777,400 = 8,517, 600 Calories chargeable against the regenerators, as the heat which they should have absorbed or intercepted. Measured by this standard, their efficiency is:

$$\frac{7,314,750}{8,517,600} = 0.86 = 86 \text{ per cent.} \qquad (1)$$

The losses from the regenerators in this view would be 7 per cent (about) by radiation and 7 per cent by *unnecessary* chimney loss.

Comparing these three methods of considering efficiency, the third appears to the writer as the fairest, and the one which gives the metallurgist the most reliable criterion of the real work which his regenerators are doing for him, and the best basis of comparison when considering the work of different regenerators or of the same regenerators under different conditions.

(2) The laboratory of the furnace, the space enclosed between the hearth, roof, side walls and ports, receives from the entering preheated gas and air their sensible heat, and the heat generated by combustion. In the case in point these items total, as already calculated:

	Calories.
Sensible heat in preheated gas.....	2,722,300
Sensible heat in preheated air.....	5,043,500
Heat generated by the combustion.....	6,202,300
Total	13,968,100
Hot products at 1,450° take out.....	10,295,000
Heat left in the laboratory.....	3,673,100

These figures show that the laboratory of the furnace appropriates to its own purposes 3,673,100 Calories out of the 13,968,100 Calories poured into it. This part of the furnace, therefore, *qua* laboratory, has an efficiency in this respect of

$$\frac{3,673,100}{13,968,100} = 0.26 = 26 \text{ per cent.} \qquad (2)$$

This is the datum which would be useful to the metallurgist in comparing the efficiencies of differently shaped laboratories,

such as those with differently shaped hearths, differently shaped roof, differently arranged ports, etc. This conception of efficiency is that taken by Damour, and repeated by Quenean in his book on "Industrial Furnaces." We must be careful here not to compare the heat left in the laboratory with the heat of combustion alone. This would give

$$\frac{3,073,100}{6,202,300} = 0.59 = 59 \text{ per cent.}$$

But this is not the heat absorption of the laboratory alone, but is a function of the furnace as a whole, and depends largely on the efficiency of the regeneration accomplished by the regenerators. If we wish to obtain an idea of the perfection with which the laboratory of the furnace appropriates the heat passing into and through it, we must simply compare what it appropriates with what was sent into it. The percentage of this appropriation measures the efficiency of the laboratory for abstracting heat for the purpose of heating itself—a datum highly useful to know if the furnace is used simply for keeping a given working space up to a given temperature for an indefinite time. If the heating of the furnace charge to the furnace heat is only a minor part of the useful work of the furnace, and keeping it at that temperature is the chief function of the furnace, then the relation of the heat thus appropriated and utilized to the total heat available to the laboratory, is a measure of the perfection of construction of the laboratory. This is the view of Damour and Queneau, and seems in some respects plausible.

However, if we are examining this question thus in detail, it appears to the writer that the view just explained and the conclusions derived therefrom may really be the very opposite of the truth of the matter, and lead to entirely erroneous conclusions. If two exactly similar open-hearth furnaces are constructed, with the sole difference that the body of one is thicker walled than the body of the other, it is perfectly true that maintaining the same temperature in each will require more gas in the thin-walled furnace, but that it will abstract and radiate a considerably larger proportion of the heat passing through it than the thick-walled furnace. Yet, according to Damour and Queneau's principle, the thin-walled furnace would be considered as being the more efficient laboratory of the two. The truth is, we must either compute the heat left in the laboratories per unit of time per cubic meter of stock space in order to compare different furnaces, or else to get absolute efficiency compute the ratio of the heat passing into the laboratory with that absorbed usefully by the charge, viz.: in this case:

$$\frac{1,447,100}{13,968,100} = 0.104 = 10.4 \text{ per cent.} \qquad (2)$$

(3) The temperature of the flame is that to which the products of combustion can be raised by the maximum heat which they contain. When perfectly consumed they contain the heat pre-existing as sensible heat in the hot gas and air, plus the heat of combustion. We have already calculated this total as 13,968,100 Calories. The mean heat capacity of the products of combustion, per 1° between 0° and t°, is:

CO^2	$1,830\ m^3\ (0.37 + 0.000022t)$	$= 677 + 0.0402t$
$O^2 + N^2$	$14,628\ m^3\ (0.303 + 0.000027t)$	$= 4.428 + 0.3950t$
H^2O	$1,500\ m^3\ (0.34 + 0.00015t)$	$= 510 + 0.2250t$
	Sum	$= 5,615 + 1.0226t$

Therefore,

$$t = \frac{13,968,100}{5,615 + 1.0226t}$$

Whence

$$t = 1,749° \qquad (3)$$

(4) If the excess air were not used, the 1,116 cubic meters of oxygen in the products, together with its corresponding quantity of nitrogen, 4,249 cubic meters, would be absent from the products of combustion, as would also some of the 211 cubic meters of water vapor. Since the oxygen in the air was 3,833 m^3 and the unused excess 1,116, the proportion of the 211 m^3 of water vapor belonging to the excess air was

$$211 \times \frac{1,116}{3,833} = 61\ m^3,$$

and the final products are CO^2 1,830 m^3, N^2 9,263 m^3 and H^2O 1,439 m^3.

The heat available will be the same as before from combustion, the same from preheated gas, but less from preheated air, because of the absence of the excess air. Since the air formerly used brought in 5,043,500, the proportion of this carried by the excess air is

$$5,043,500 \times \frac{1,116}{3,833} = 1,468,500,$$

leaving heat brought in by air in the second case the difference, viz.: 3,575,000, and the total heat in the products 13,968,100 — 1,468,500 = 12,499,600 Calories.

The mean heat capacity of the diminished quantity of products, per 1°, is, by the same methods as previously used, $3.973 + 0.8685t$, and, therefore,

$$t = \frac{12,499,600}{3.973 + 0.8685t} = 2,142° \qquad (4)$$

a gain of nearly 400° in maximum temperature, by cutting off the 40 per cent excess of air which was being used.

Problem 71.

The new style Siemens furnace for small plants has the gas producers built in as part of the furnace, between the two regenerators. The furnace has only one regenerative chamber at each end for preheating the air used for burning the gas, while the latter comes to the ports hot directly from the producers. This plant is compact, economical of fuel, allows high temperatures to be reached, and occupies little floor space. As compared with the old style separate furnace and producer plant, it occupies about half the floor space, costs about 60 per cent as much to build and uses about 60 per cent as much coal. They are largely used abroad for melting steel for castings in small foundries and for melting pig iron for castings to be subsequently annealed to malleable castings.

Such a furnace melted a charge of 3,000 kilograms of cast iron in 4 hours, using 750 kilograms of coal. The cast iron was charged cold, at 0°, and run out melted at 1,450°, containing 300 Calories of sensible heat per kilogram. The coal and gases were of the following composition:

Coal—C 75, H 5, O 12, H^2O 2, ash 6.

Producer Gas—CO 20, CO^2 5, CH^4 2, H^2 16, N^2 57.

Chimney Gas—CO^2 10, O^2 8, N^2 79.2.

The air coming to the furnace is at 0° and dry; a steam blower is used to run the producer, using 1 kilo. of steam per 6 kilos. of air blown in, and the raising of this steam requires 0.1 kilo. of coal used under boilers. The ashes produced weigh 75 kilos. per heat run. Temperature of the hot producer gas entering the furnace laboratory 600°, of preheated air 1,000°, of products leaving laboratory 1,400°, of products entering chimney flue 350°.

Required:

(1) A heat balance sheet of the furnace as a whole.

(2) The net thermal efficiency of the furnace.

(3) The net thermal efficiency of the laboratory of the furnace.

(4) The net thermal efficiency of the regenerators.

(5) The theoretical flame temperature in the furnace.

Solution:

(1) Heat balance sheet per charge of 3,000 kilos.

Heat Available.

	Calories.
Calorific power of coal used in producers....	5,248,500
Calorific power of coal used under boilers...	398,900
	5,647,400

Heat Distribution.

In melted cast iron..	900,000
In chimney products.	768,950
Loss by unburnt carbon in ashes..	243,000
Used for raising steam..	398,900
Loss by radiation and conduction.	3,336,550
	5,647,400

Calculation of the Heat Balance.

The heat of combustion of a kilogram of coal is not given, therefore must be calculated from its composition:

		Calories.
C 0.75 × 8,000	=	6,075
$H\left(0.05 - \frac{0.12}{8}\right) \times 34{,}500$	=	1,208
Calorific power to liquid water	=	7,283
Vaporization heat of water formed (0.02 + 0.45) × 606.5	=	285
Calorific power to vapor of water	=	6,998
Of 750 kilos. in the producers	=	5,248,500

The coal used under the boilers can only be found by first finding how much steam was used, which in its turn can be gotten from the air blown in, and the nitrogen of this can be found from the total nitrogen in the producer gas. The volume of producer gas can be gotten from its carbon content per cubic meter and the known weight of carbon gasified. Or, turning this chain of reasoning the other way, if we subtract the carbon in the ashes from the carbon in the coal, the difference is the carbon entering the gases; this divided by the carbon in 1 cubic meter of chimney gas (calculated from its analysis) gives the volume of chimney gas, and by the carbon in 1 cubic meter of producer gas gives the volume of this gas used, from which the nitrogen in it can be calculated, which divided by 0.792 gives the volume of air used, from which its weight is obtained, thence the amount of steam used, and finally from this the amount of coal necessary to burn under boilers to raise this steam.

[In working most metallurgical problems the difficulty of finding the connection or succession of steps connecting the requirements with the data given is often easiest overcome by starting with the requirement in mind and noting from what other figure its value may be calculated, and thus passing backwards from one figure to another we finally arrive at one which can be found directly from the data given. The logical sequence of operations is thus disclosed and the problem is in reality solved; the following of the thread in the reverse direction, from data to requirement, involves calculations only, not hard thinking, and is usually a matter of the simplest arithmetic.]

The operations for calculating the steam used are as follows:

Carbon in coal in producers = 750 × 0.75	=	562.5 kg.
Carbon in ashes from producers = 75 — 45	=	30.0 "
Carbon in gases from producers	=	532.5 "
Carbon in producer gas per 1 m^3 = 0.27 × 0.54	=	0.1458 "
Producer gas per heat = 532.5 ÷ 0.1458	=	3,652 m^3
Nitrogen in producer gas = 3,652 × 0.57	=	2,082 "
Air used in the producer = 2,082 ÷ 0.792	=	2,629 "
	=	3,399 kg.
Carbon in chimney gas per 1 m^3 = 0.19 × 0.54	=	0.1026 "
Chimney gas per heat = 532.5 ÷ 0.1026	=	5,190 m^3
Nitrogen in chimney gas = 5,190 × 0.792	=	4,110 m^3
Nitrogen from air used = 4,110 — 2,082	=	2,028 "
Air used to burn gas = 2,028 ÷ 0.792	=	2,561 "
Weight of this air = 2,561 × 1.293	=	3,311 kg.
Weight of air used in producer	=	3,399 "
Weight of steam used in producer = 3,399 ÷ 6	=	567 "
Weight of boiler coal used = 567 × 0.1	=	57 "
Calorific power of this coal = 6,998 × 57	=	398,900 Cal.

The heat in the melted cast iron is simply its weight times 300 = 300 × 3,000 = 900,000 Calories.

(2) The net thermal efficiency follows directly from this, as

$$\frac{900{,}000}{5{,}647{,}400} = 0.16 = 16 \text{ per cent.} \qquad (2)$$

(3) The gaseous products consist dry, as analysed, of

CO^2	5,190 × 0.19 =	986 m^3
O^2	5,190 × 0.018 =	93 "
N^2	5,190 × 0.792 =	4,110 "

And in addition all the water formed from the coal, plus the steam used, a total of:

Water from coal = 0.47 × 750	= 352.5 kg.
Steam	= 566.5 "
Total water vapor in gases	= 919.0 "

Volume at standard conditions = 919 ÷ 0.81 = 1,135 m^3

At 350° these products carry out of the furnace heat as follows:

		Calories.
$O^2 + N^2$	4.203 × 0.312 =	1,311
CO^2	986 × 0.447 =	441
H^2O	1,135 × 0.392 =	445

Average caloric capacity per 1° = 2,197

Capacity per 350° = 768,950 Calories.

These same products would carry heat out of the laboratory of the furnace at 1,400° as follows:

		Calories.
$O^2 + N^2$	4.203 × 0.341 =	1,433
CO^2	986 × 0.678 =	669
H^2O	1.135 × 0.550 =	624

Average caloric capacity per 1° = 2,726

Capacity per 1,400° = 3,816,400 Calories.

The heat developed in the laboratory of the furnace by the combustion of the 3.652 m^3 of producer gas is

		Calories.
CO	0.20 × 3,062 =	612
CH^4	0.02 × 8,598 =	172
H^2	0.16 × 2,613 =	418
Per 1 m^3	=	1,202

Per 3.652 m^3 = 4,389,700 Calories.

The 3,652 m^3 of gas comes into the laboratory of the furnace at 600°, and therefore carries in as sensible heat the following:

CO^2	0.05 × 0.502 = 0.0251	Cal. per 1°
CH^4	0.02 × 0.512 = 0.0102	" "
CO, N^2, H^2	0.93 × 0.319 = 0.2967	" "
	0.3320 × 600 = 199.2	Cal

Per 3,652 m^3 = 199.2 × 3.652 = 727,480 Calories.

This does not count, however, the water vapor accompanying the producer gas. This is best determined from the fact that the total hydrogen in the coal and steam used in the producer must appear as hydrogen in the producer gas in some form or other, and whatever is not present in the dry producer gas must be in the water vapor accompanying it. The amount of this and the heat it carries into the laboratory of the furnace are thus determined:

Hydrogen in 750 kg. coal = 750 × 0.0522 = 39.15 kg.
Hydrogen in steam used = 567 ÷ 9 = 63.00 "
Hydrogen going into producer gases = 102.15 "
Hydrogen in dry producer gases,
3,652 × 0.20 × 0.09 = 65.74 "
Hydrogen in producer gas as vapor of
water = 36.41 "
Water vapor in producer gas = 327.7 "
Volume of this vapor = 405 m^3
Heat in this at 600 , 405 × 0.43 × 600 = 104,500 Cal.
Total heat in moist producer gas,
727,480 + 104,500 = 831,980 "

We must also calculate the heat brought into the laboratory of the furnace by the preheated air, at 1,000°, used for combustion. This is

2,561 m^3 × 0.330 × 1,000 = 845,130 Calories.

It follows from the above calculations that the laboratory of the furnace receives per heat of steel:

	Calories.
From hot producer gas at 600	= 831,980
From preheated air at 1,000°	= 845,130
From combustion	= 4,389,700
Total	= 6,066,810

Of this total there is rejected in the hot products at 1,400°, 3,816,400 Calories, leaving in the laboratory of the furnace 2,250,410 Calories.

According to the view of Damour and Queneau (Industrial Furnaces, page 56) the ratio of the heat thus left in the body of the furnace to the calorific power of the fuel used, measures the thermal efficiency of the furnace. According to that view this new style Siemen's furnace has an efficiency of

$$\frac{2,250,410}{5,647,400} = 0.400 = 40.0 \text{ per cent.}$$

This figure, however, is an illusive one. It enables us to compare two furnaces and see which regenerates the waste heat best, or which furnace laboratory is designed best so as to catch and retain most of the heat furnished to it; but the real question is the comparison of different laboratories as to their net melting efficiency. This laboratory abstracts from the heat supply furnished to it 2,250,410 Calories, and furnishes to the steel 900,000 Calories. Its proportion of usefully applied heat to heat appropriated is, therefore:

$$\frac{900,000}{2,250,410} = 0.400 = 40.0 \text{ per cent.} \quad (3)$$

The laboratory of the furnace therefore loses by radiation 60 per cent of the heat which it abstracts from the gases, or 2,250,410 — 900,000 = 1,350,410 Calories. This is 24 per cent of the calorific power of the coal used.

(4) The regenerators receive 3,816,400 Calories from the laboratory of the furnace, and return to it the heat in the preheated air at 1,000°, viz.: 845,130 Calories. If we call the ratio of these two the efficiency of the regenerators we have

$$\frac{845,130}{3,816,400} = 0.222 = 22.2 \text{ per cent.}$$

If, however, we charge them only with the heat actually left in them by the hot products, entering at 1,400° and leaving at 350°, we have an efficiency of

$$\frac{845,130}{3,816,400 - 768,950} = 0.277 = 27.7 \text{ per cent.} \quad (4)$$

As long as the chimney gases are near in temperature to 300°, we can use the latter form of calculation as representing the real efficiency of the regenerator. The regenerators, therefore, lose by radiation and conduction to the air 2,202,320 Calories, which is 72.3 per cent of the heat left in them by the hot gases and 39 per cent of the calorific power of the coal used.

(5) The flame temperature is that to which the 6,066,810 Calories available in the laboratory of the furnace will raise the products of combustion. The average mean specific heat of the latter per 1° is:

CO^2 986 m^3 × (0.37 + 0.000022t) = 365 + 0.2169t
$O^2 + N^2$ 4,203 m^3 × (0.303 + 0.000027t) = 1,274 + 0.1135t
H^2O 1,135 m^3 × (0.34 + 0.00015t) = 386 + 0.1703t
Sum = 2,025 + 0.5008t

$$\text{Therefore} \quad t = \frac{6,066,810}{2,025 + 0.5008t}$$

Whence $t = 2,003°$ (5)

Problem 72.

In an basic lined open-hearth furnace using the Monell process, 50 short tons of melted pig iron, at 1,300°, is run upon 30,000 pounds of Lake Superior iron ore (90 per cent Fe^2O^3, 10 per cent SiO^2) lying on the hearth and previously heated to 1,300°. There is 2,000 pounds of burnt lime lying on the ore to help to form slag. The ore reacted quickly, almost violently, on the melted pig iron, so that at the close of the reaction, in 20 minutes, the slag could be run off. The pig iron contained.

	On Running in.	*After the Reaction.*
Carbon	3.50	3.00
Silicon	2.00	0.00
Phosphorus	0.75	0.00
Manganese	0.50	0.00
Iron	93.25	97.00

The oxidation of C, Si, P and Mn may be assumed as being produced first by reducing all Fe^2O^3 present to FeO, and completed by the reduction of some FeO to Fe. The carbon is assumed oxidized in the reaction to CO, although this CO may be subsequently partly burned to CO^2 by excess air in the furnace.

Required:

(1) The amount of iron reduced into the bath.

(2) The weight and percentage composition of the slag formed.

(3) The items of heat evolved and absorbed in the reaction.

Solution:

(1) We cannot make a simple, direct solution, because the weight of the metal after the reaction, analysis of which is given, is not known. The inexperienced calculator might be tempted to say that there was 3.50 — 3.00 = 0.50 per cent of carbon oxidized, 2.00 per cent of silicon, 0.75 per cent of phosphorus and 0.50 per cent of manganese, calculate the weights of these, reckon up the oxygen they would absorb in being oxidized, and thus get at the amount of Fe^2O^3 reduced to FeO and FeO reduced to Fe. This would be correct as far as silicon, manganese and phosphorus are concerned, because they are entirely oxidized, but incorrect for the weight of carbon, because the 3.00 per cent not oxidized is per cent of the final bath, which is of different weight from the original one, and, therefore, we are in error in subtracting 3.00 from 3.50. Being confronted with this dilemma we can see, however, that if we only knew the weight of the bath after the reaction we could calculate correctly how much carbon is in it, thence get the correct weight of carbon oxidized, then the correct amount of oxygen absorbed in the reaction, and from this the weight of iron reduced into the bath. We could also get the latter quantity more simply by finding the iron present in the bath after the reaction (97 per cent), and subtracting from it the iron in the original bath. We thus have two ways of getting the same requirement if we only knew the weight of the bath. In such a case the mathematical key to the situation is, of course, to let X represent the weight of the bath, and work out the amount of iron reduced into the bath by the two methods,

getting the result expressed in each case in terms of X. Since the two expressions represent the same quantity, we put them equal to each other and solve for X. Having obtained X, we substitute it in other expression and get the result asked for.

Let X be the weight of the bath after the reaction, in pounds; the bath before the reaction weighs 100,000 pounds.

Oxidized out:

Carbon (100,000 × 0.035) — X 0.03	= 3,500 — 0.03 X	pounds.
Silicon 100,000 × 0.02	= 2,000	"
Phorphorus 100,000 × 0.0075	= 750	"
Manganese 100,000 × 0.005	= 500	"

Oxygen required:

For carbon (3,500 — 0.03 X) 16/12	= 4,677 — 0.04 X	pounds.
For silicon 2,000 × 32/28	= 2,286	"
For phosphorus 750 × 80/62	= 968	"
For manganese 500 × 16/55	= 145	"
Sum	= 8,076 — 0.04 X	pounds.

Oxygen supplied:

If all Fe^2O^3 of ore (27,000 pounds) were reduced to FeO = 27,000 × 16/160 = 2,700 pounds.

If all Fe^2O^3 of ore were reduced to Fe 27,000 × 48/160 = 8,100 pounds.

We thus see that we will certainly require more oxygen than the Fe^2O^3 can give up in becoming all FeO, but not as much as would be given up if it all became Fe. If all the Fe^2O^3 were considered first reduced by the reaction to FeO, giving up 2,700 pounds of oxygen, the reaction will still require the furnishing of

$$(8.076 - 0.04\ X) - 2{,}700 = 5{,}376 - 0.04\ X \text{ pounds}$$

of oxygen, which would have to be furnished by FeO becoming Fe. In that reduction, however, 72 parts of FeO gives up 16 of oxygen in becoming 56 Fe. The reduced Fe will be, therefore, 56/16 of the weight of oxygen thus furnished, and therefore,

$$\text{Reduced Fe} = 56/16\ (5{,}376 - 0.04\ X) \text{ pounds.}$$
$$= 18{,}816 - 0.14\ X \text{ pounds.}$$

The same quantity is obtained more directly as follows:

Fe in original bath 100,000 × 0.9325	= 93,250	pounds.
Fe in bath after reaction	= 0.97 X	pounds.
Therefore, Fe reduced	= 0.97 X — 93,250	lbs.

These two expressions represent the same thing, and, therefore,

$$18{,}816 - 0.14\ X = 0.97\ X - 93{,}250$$

Whence $X = 100{,}960$

And the reduced iron = 0.97 X — 93,250 = 4,681 pounds. (1)

(2) The ore used contains altogether

Fe = 27,000 × 112/160	= 18,900 lbs.		
Fe reduced to metallic state	= 4,681 "		
Fe remaining in slag as FeO	= 14,219 "		
Weight of FeO = 14,219 × 72/56	= 18,282 "	= 61.1	per cent.
Weight of P^2O^5 = 750 + 968	= 1,718 "	= 5.7	"
Weight of MnO = 500 + 145	= 645 "	= 2.1	"
Weight of CaO	= 2,000 "	= 6.7	"
Weight of SiO^2 = 3,000 + 4,286	= 7,286 "	= 24.4	"
Total weight of slag	= 29,931 "		(2)

(3) The physical data available do not permit of calculating the actual heat of the reaction at 1,300°, since many of the specific heats needed are lacking. We will therefore foot up the items of heat evolution and absorption uncorrected for temperature, which is the only thing to be done under the circumstances.

Heat Evolution.

		Calories.
Si to SiO	2,000 × 7,000	= 14,000,000
P to P^2O^5	750 × 5,892	= 4,419,000
Mn to MnO	500 × 1,653	= 826,500
C to CO	471 × 2,430	= 1,144,500
SiO^2 to FeO. SiO^2	7,286 × 144	= 1,049,200
CaO to $3CaO.\ P^2O^5$	2,000 × 949	= 1,898,000
Total		= 23,337,200

Heat Absorption.

		Calories.
Fe^2O^3 to FeO	18,900 × 573	= 10,829,700
FeO to Fe	4,681 × 1,173	= 5,490,800
Fe^3C to Fe^3 + C	471 × 705 (?)	= 332,000 (?)
FeSi to Fe + Si	2,000 × 931 (??)	= 1,682,000 (??)
Fe^3P to Fe^3 + P	750 × 1,400 (??)	= 1,050,000 (??)
Sum		= 19,564,500

These calculations, therefore, show a minimum surplus of heat in the reaction of 23,337,200 — 19,564,500 = 3,772,700 Cal., an amount which would raise the temperature of the slag and resulting metal approximately 100° C. above the 1,300° at which the reacting materials came together. The quantity above marked (?) is a little doubtful in amount, but those marked (??) are very doubtful, perhaps may not exist at all. If these are omitted from the heat absorption the surplus heat is increased some 50 per cent of its value, and the rise in temperature might be in the neighborhood of 150°. Further, some of the CO formed by the oxidation of carbon may be burned to CO^2 close to the surface of the bath, by free oxygen in the furnace, still further increasing the rise in temperature.

The conclusion from these calculations and discussions is that the pig iron and ore reaction in the Monell process is a heat evolving reaction, which, independently of the heating effect of the fuel used by the furnace, could increase the temperature of the contents of the furnace at least 100°, and possibly 150°. It would be highly interesting to have a typical heat such as this followed closely with a good reliable pyrometer, so as to check the indications of the thermochemical study of the process.

[The next instalment of these calculations will be upon the electrical methods of melting iron and steel, electro-thermal processes of reducing iron ore and the electrolytic refining of iron.]

Magnetic Separation of Iron Ores by the Gröndal Process.

By P. McN. Bennie.

Development of the Gröndal Process.

About twenty years ago the question of iron ore supplies became serious, and at that time magnetic separation received considerable attention from Conkling, Ball and Norton, and others, with the idea of utilizing large bodies of magnetic iron ore which could only be made available by means of magnetic concentration.

Then came the rapid development of the immense bodies of Lake ore, of a quality which could advantageously be used in the blast furnace, and, except in certain restricted districts, interest in magnetic ores was lost. About the same time there was some hope that the magnetic iron ore deposits in Ontario would receive serious development, and indeed a number of fairly large shipments were made to the United States. But the development of the Lake ore bodies practically closed that market, and work on the Ontario mines declined to insignificance. In fact the discovery of those same Lake Superior ore bodies has had an influence upon the metallurgical life of both Canada and the United States, but little appreciated nowadays.

In European countries, however, especially in Sweden, conditions were different. The supply of suitable ores ready

*A paper read before the Canadian Mining Institute, slightly abstracted.

for blast-furnace use in their natural conditions was limited and low grade; in many cases highly phosphatic and sulphurous ores had to be used; consequently great efforts have been made to perfect concentrating methods. The attention of many prominent engineers and metallurgists has been turned, with more or less success, towards the solution of the difficult problems involved in turning to account these ore supplies.

Mr. Gustaf Gröndal's efforts in this direction, extending over a number of years, have been quite successful, the appliances and machinery invented by him for crushing, concentrating and briquetting low grade and impure iron ores being now so perfected as to constitute a complete commercial process. By these methods a great many hitherto practically valueless iron ores can be turned to excellent account by reason of the richness and purity of the concentrates and briquets produced, and the comparatively low cost of production.

FIG. 1.—GENERAL VIEW OF HERRÄNG IRON WORKS.

Primarily the Gröndal processes permit of the economic use of the many, in some cases immense, deposits of iron ore which are found in various places throughout the world, and which are unsuitable in their native state, owing to some objectionable characteristic, for economic blast-furnace practice, and the production of good quality pig iron. Usually, the objection to their use will be found to be one of the following: First, that the ore is too low in iron content; second, that it contains impurities which cannot be eliminated in the blast furnace; third, that it occurs in a mechanical condition unsuitable for blast furnace use, except to a limited extent: such as iron sands and small ores generally.

Among the ores which may be commercially utilized by the Gröndal processes may be instanced:

Magnetites of all kinds, including magnetic iron sands, containing as low as 25 per cent iron.

Magnetites containing a high percentage of phosphorus and copper not chemically combined with the iron.

Purple ore and pyrites residues.

Nearly all kinds of iron ores containing a high percentage of sulphur.

Flue dust.

The Gröndal Concentrating Process.

The scheme of treatment is briefly as follows:

1. The ore is crushed dry to about ½-inch cube or thereabouts.

2. Wet treatment in a Gröndal ball mill, which reduces the ore from the crushed size to 10 to 100-mesh as may be found necessary.

3. The ground pulp is passed through a Gröndal magnetic separator where the non-magnetic particles are removed.

4. The concentrates are pressed into briquets and heated in the Gröndal briquetting kiln, from which they issue as hard, porous, easily reducible, ferric oxide briquets, with a minimum percentage of sulphur.

To take each operation in detail:

Any good type of commercial crusher may be used in the preliminary crushing of the ore. Usually either a Gates or Blake crusher is employed.

The broken ore is conveyed and distributed to the feed hoppers of the Gröndal ball mills. The feeding arrangement consists of an ordinary roller feeder driver at a uniform speed and so constructed as to admit of accurate adjustment of feed. The ball mill consists of a hollow cylinder, 4 feet in diameter and varying in width from 4 to 8 feet. It is reinforced with steel ribs and lined with manganese steel, or other steel alloy of good wearing quality. The mill is charged with about 2 tons of chilled cast-iron balls, of about 6 inches diameter.

The ends are of cast iron, with suitable openings provided with a screen at the discharge end. The degree of fineness of the ore is regulated by varying the amount of water introduced into the mill.

It is found that working with ores of average hardness the consumption of iron, represented mainly by the wear on the balls, amounts to about 2 pounds per ton of ore treated.

The mills require from 20 to 25 hp. each; make from twenty-five to thirty revolutions per minute, and grind from 50 to 100 tons of ore per 24 hours, from ½ inch down to from 10 to 100-mesh in fineness.

In order to free the pulp from the bulk of the non-magnetic climes, it is often advisable to pass the pulp coming from the ball mill through a slime-box before charging it into the separator proper. The slime-box consists of a V-shaped box, the plup entering at the top and a stream of water at the bottom. The slime boxes are usually built in pairs, and between each pair is placed an electromagnet with a hatchet-shaped pole piece. This electromagnet is of such strength as just not to lift any magnetic particles out of the water. The velocities of the pulp and clear water are so arranged that the heavier particles settle at the bottom, from whence they are drawn off to the separator. The function of the magnet is to arrest magnetic particles in the fine slimes which collect on the surface of the water immediately under the pole piece in masses,

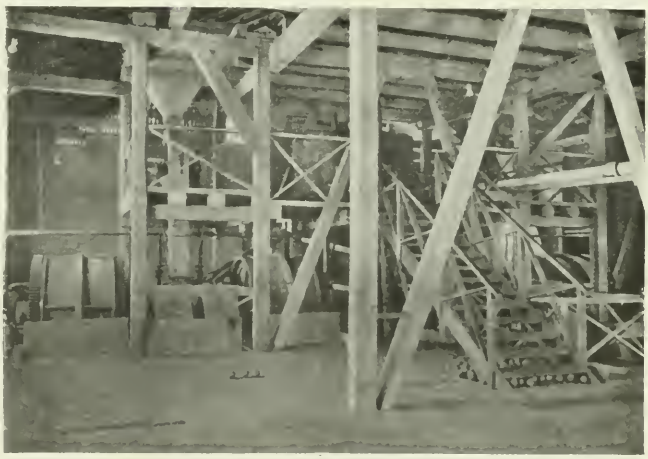


FIG. 2.—BALL MILLS AT HERRÄNG.

and from time to time drop to the bottom whence they are carried off with the main pulp to the separators.

The diagram of Fig. 3 shows the principle of the separator proper. S representing the slimes, M the magnet, C the concentrates, T the tailings. The pulp feed from slimes passes to this part of the apparatus. This consists of a series of magnets with flat pole pieces arranged with their N and S poles alternately. The magnets are enclosed in a plain brass drum. This drum is made to rotate at a speed of from 80 to 100

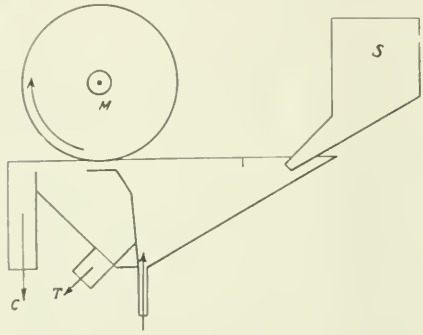


FIG. 3.—PRINCIPLE OF GRÖNDAL SEPARATOR.

revolutions per minute, and about 1 inch above the surface of the pulp, which traverses a pyramidal box divided into two compartments by a partition reaching nearly to the top of the box. The pulp enters at the top of the box, and a stream of water entering at the bottom and rising up on the same side of the partition carried all the pulp well over the edge of the latter and thus immediately under the drum.

The magnets within the drum powerfully attract and bring the magnetic particles out of the stream of pulp and against the revolving brass drum. The remainder of the pulp drops down on the other side of the partition, and is carried off by the water through the waste outlet. The magnetic particles are lifted by the drum to the very edge of the magnetic field, where they are thrown off centrifugally. The capacity of the double drum separator (which is the form commonly used) is from 70 to 100 tons of ore per 24 hours; it requires about 6 amps. at 120 volts, or, say, 1 hp., while less than ¼ hp. will drive the drums.

A plant consisting of four ball mills, four double-drum separators, and having a capacity of fully 200 tons of concentrates per 24 hours, would require approximately 180 gallons of water per minute, and a power plant generating 150 electric horse power would be ample for all the motive power required.

The concentration process reduces the percentage of phosphorus more or less, depending upon the mineral form in which it occurs in the ore. In most magnetites it is found in the form of apatite, in which case the phosphorus can be almost entirely eliminated. For example, at Gellivare Sweden, the phosphorus is reduced from 1.29 in the crude ore to 0.005 in the concentrates, and 0.006 in the briquets. The percentage of iron is raised to a high figure, and at the same time the amount of slag-forming minerals is lowered. As a result the ore is more easily reduced in the furnace, and requires less fuel per ton of iron.

The quality of the pig iron will be quite materially improved when employing purer ore and less fuel than ordinarily.

Sometime the ore mined is a mixture of magnetite and hematite. The dry magnetic concentrating methods hitherto employed give rather unsatisfactory results as regards the iron content of the tailing. With the Gröndal concentrating process, where the ore is already slimed up in water, a retreatment of the tailings on jigs or slime tables can be carried out with advantage, thus increasing the output of the plant without crushing or grinding any additional tonnage of ore.

The Gröndal concentrating process can be regarded as practically the only existing method for the economic treatment of low-grade ores in which the magnetite is so finely and intimately mixed with the gangue that the ore has to be crushed down to less than twenty mesh before it can be separated. Take the case of the banded jasper ore in the Temagami district, which would require very fine grinding to effect an economic recovery of iron: the Gröndal process could do this, where no other could. But it is also obvious that such fine ores must be briquetted.

The Gröndal Briquetting Process.

Concentrates produced by this process, iron sands, pyrites residues, small ores generally, as well as ores containing a high percentage of sulphur, which are unsuited for use in the blast furnace, are next briquetted.

The material is conveyed to the briquetting presses. These are drop presses, the height of the drop being from 6½ to 7½ inches, and the briquets receive three blows, the falling weight being about 1,800 pounds. The briquets may be of various sizes, but are usually made 6 inches x 6 inches x 3 inches, weighing from 8 to 10 pounds each. Each press requires 3 electric horse-power, and will make from 500 to 750 briquets per hour. The pulverized ore is pressed into briquets without any binding material whatever, the moisture in the ore being so adjusted as to obtain briquets sufficiently firm to be removed from this press to the cars used in the furnace.

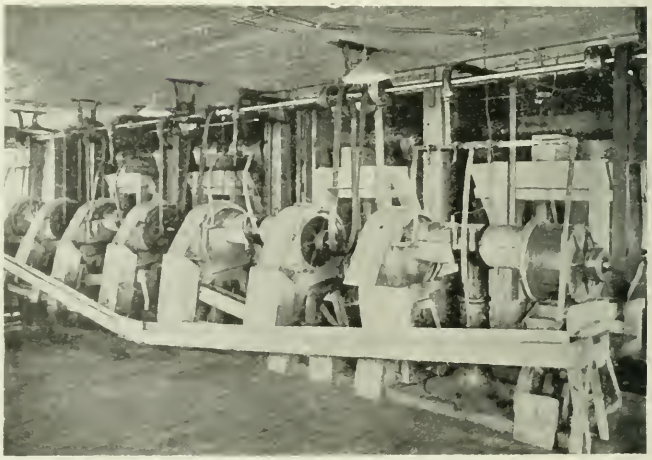


FIG. 4.—MAGNETIC SEPARATORS AT HERRÄNG.

The briquets are taken from the press and placed on the furnace cars. These are made of iron and covered with firebrick. Along each side of the car is a deep flange, which dips into a channel filled with sand placed along the sides of the furnace, thus forming a gas-tight seal. The ends of adjacent cars are fitted with a groove and projecting rib respectively. By this means the surface of the cars forms a gas-tight partition and thus prevents the power portion of the cars, frame, wheels, etc., from becoming heated. The cars measure 3 feet 6 inches,

and hold from 15 to 16 hundredweight of briquets, arranged on edge in two piers.

The Furnace.

The furnace is fired by gas derived preferably from gas producers, although blast furnace gas can be used. The combustion chamber is situated about one-third of the length from the in-take end. The air needed for combustion is introduced below and traverses the row of cars, thus helping to keep the wheels and framework cool, and at the end of the furnace is diverted to the top of the row of cars, traversing

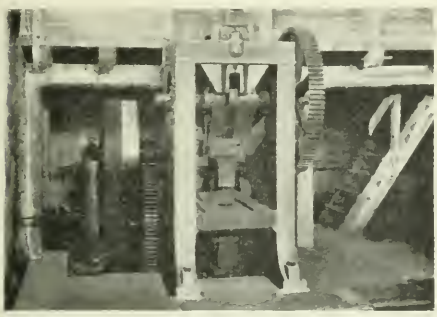


FIG. 5.—BRIQUETTING PRESS.

the burnt briquets, cooling them and becoming itself heated before reaching the combustion chamber. The products of combustion pass over the entering cars, assist in drying and heating the briquets, and finally escape through a stack at a temperature of only 150° C.

The furnace being thus constructed on the regenerative principle, has a very good thermal efficiency, radiation is small, and the chief loss of heat is due to the evaporation of the water contained in the briquets (5 to 7 per cent). A car of finished briquets is drawn about every half hour, depending somewhat on the degree of desulphurization required. Recently furnaces have been arranged so as to give a continuous movement to the cars, increasing the capacity of the furnace considerably.

The temperature in the combustion chamber of the briquetting furnace reaches 1,300° to 1,400° C. At this heat the particles agglutinate sufficiently to form a firm, hard briquet, able to stand rough handling and long transport. The briquets though hard are very porous, and are, consequently, far more easily reduced in the blast furnace than ordinary lump ore. The briquet made from Herräng ore, exhibited here, has a porosity of 23.9 per cent of its volume.

When briquetting iron ore concentrates and using producer gas for fuel, the consumption of coal has been found to average 7 per cent of the weight of briquets burnt.

Gröndal Briquets.

The Gröndal briquet is unique in that it does not contain an added binder, and therefore there is no foreign material such as lime to be heated and slagged off. In the case of magnetic oxide concentrates the particles are completely peroxidized, owing to the very free supply of air given to the furnace during the process of burning the briquets. Such peroxidized ore is very easily reduced in the furnace, thus introducing a certain fuel economy.

Treatment of Pyrites Residues.

Briquets made by this process from pyrites residues and purple ore have proved to be entirely satisfactory in the open-hearth steel furnace. At Cwmavon ores containing 2 to 4 per cent sulphur, and sometimes more, are being successfully treated by this process.

Capacity of Furnace.

The output of one furnace varies from 30 to 80 tons in 24 hours, according to the class of ore used and the degree of desulphurization required; for in addition to its mechanical action this furnace acts as an exceptionally efficient calciner for removing practically all of the sulphur.

Results of Treatment.

The following analyses of crude ore concentrates and briquets give an idea of the results obtained by the Gröndal processes. In addition to the figures, given below for the results obtained at Herräng, it may be said that the tailings from the Herräng ore, after passing through the magnetic separator, analyzed 9.6 per cent iron. The porosity in per cent of volume of briquets was 23.9:

	Iron.	*Sulphur*	*Phosphorus.*
Herräng, Sweden—			
Crude ore	40.00	1.20	0.003
Concentrates	65.20	0.17	0.0025
Briquets	63.01	0.003	0.0025
Gellivare, Sweden—			
Crude ore	58.96	0.036	1.29
Concentrates	72.38	0.003	0.005
Briquets	69.49	0.002	0.006
Salengen, Norway—			
Crude ore	36.43	0.021	0.318
Concentrates	71.76	0.015	0.008
Briquets	....	....	....
Pitkaranta, Finland—			
Crude ore	28.40	2.60	0.260
Concentrates	69.59	0.132	0.007
Briquets	67.98	0.011	0.008
Cornwall, Penn.—			
Crude ore	30.65	1.603	0.012
Concentrates	69.95	0.036	0.003
Briquets	69.90	0.010	0.005

The results from Cornwall ore were obtained with a 10-ton

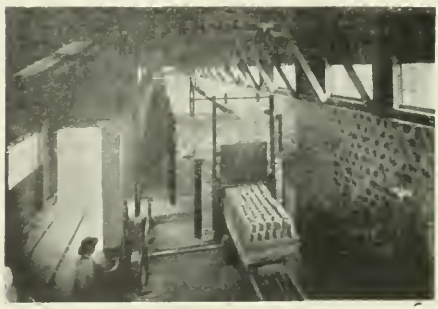


FIG. 6.—BRIQUETTING FURNACE AT GULDSMEDSHYTTAN.

sample sent to Herräng about a year ago, as there is not yet a plant available on this side of the Atlantic.

Separation of Titanium.

Last June we constructed a small separator on the Gröndal principle at our Canadian laboratory. Some tests were made on the separation of titanium from ore, working with what are known as Metis Beach Sands, from the St. Lawrence River. We got the following results:

Original	16.57 per cent TiO_2
Concentrates	4.21 "
Middlings	19.48 "

It should be remarked that the concentrates were obtained by a single passage through the separator. Doubtless even better

results could be obtained from a finer grinding, and repassing through the separator.

Cost of Plant.

It is impossible to give anything but bare approximations as to cost of plant, which varies considerably with the local situation and conditions. The figures quoted are based upon cost of materials and cost of erection in the United States:

For 200 tons of concentrates per day:

Concentrating plant for 400/500 tons of crude ore per day	$45,000
Briquetting plant for 200 tons of concentrates in 24 hours	65,000
	$110,000

For 100 tons of concentrate per day these figures would be about $27,000 and $39,000, respectively, a total of $66,000.

Cost of Concentrating.

The cost of concentrating will naturally vary with the character of the ore treated, and the amount of iron contained in same. Assuming the treatment of an average magnetic iron ore, containing 40 per cent iron, and the production of a concentrate carrying about 63 per cent iron, the cost of concentrating varies from 30 to 45 cents per ton of concentrates. These figures refer to the mechanical treatment only and exclude the cost of ore.

Cost of Briquetting.

The cost of briquetting is also an item varying with local conditions. A briquetting plant of 200 tons daily capacity would consist of four to seven furnaces, depending upon the ore, and to a large extent on the amount of sulphur to be removed. The cost per ton for briquetting can be taken, under normal conditions, as varying between 45 and 85 cents per ton.

At a small plant consisting of one furnace, producing 25 to 30 tons per day, the actual cost, including labor, coal, rent and taxes, but exclusive of depreciation and royalty, amounts to 85 cents. This plant is working on pyrites residues, and owing to its small size and the nature of the work the cost is very high.

On the other hand, at a typical plant in Sweden, turning out 120 tons of briquets daily, the cost of briquetting amounts to 77 cents per ton. At one of the Swedish plants of recent construction the cost has been reduced to 67 cents per ton.

Recently the briquetting furnace has been simplified and improved so as to materially decrease the cost of installation, and at the same time to lower the cost of briquetting.

Treatment of Canadian Ores.

The present situation in Canada, and particularly in the province of Ontario, is similar to that in the Scandinavian countries in many ways. Not over blessed with ready fuel, and with iron ores that in many instances require concentration, yet it is well known that certain qualities of iron (Swedish pig, for example) are produced, which bring a premium on the market. There is no reason why Canada should not largely augment its production of high-grade pig iron, and have as great a demand for it as for the Swedish article.

There are many bodies of magnetic iron ore in Ontario, running from 35 to 50 per cent iron, that would be so improved by proper treatment as to produce premium ores, for which there is now, and probably will continue to be, a brisk demand.

For ores that demand fine grinding to recover an economical percentage of iron content, the Gröndal briquet affords a means of converting unsalable ores into an article that will actually bring a premium, thus helping to pay for the cost of treatment. Only recently a blast furnace manager told me he would be glad to get 200 tons a day of such briquets. Gröndal briquets are now being shipped in considerable quantities from Sweden to Great Britain, where they command an instant market at prices above the average.

Electrothermic Processes.

Another feature certain to be of considerable economic value to Canada is the application of electrothermic processes for producing high-grade pig iron and steel. Broadly speaking, the use of sufficient electrical energy to produce 1 ton of pig iron in the electric furnace means the displacement of about 1,600 pounds of fuel. Coal once used is gone forever, while water powers maintain themselves by a natural process, a fact of great economic importance to Canada. The fortunate existence, practically side by side, of iron mines and extensive water powers, produce conditions very favorable to the electrothermic process. I think the Government would do well to foster the development of that branch of metallurgy as much as possible, to enable the country to realize on its natural and unique resources.

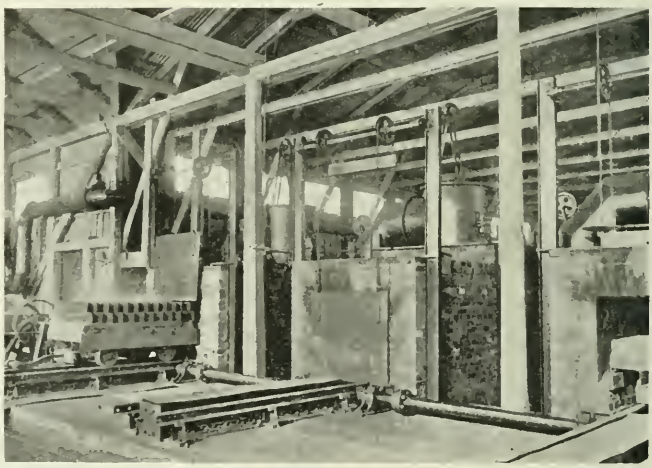


FIG. 7.—RANGE OF BRIQUETTING FURNACES AT HERRÄNG.

Many of the ores could doubtless be used direct, others would require concentration, and still others would have to be briquetted, but the economy of producing finished material wherever possible "on the spot" is obvious. Science and art have now placed in the hands of those who will, means of utilizing these resources, and thus adding to the nation's wealth.

FitzGerald & Bennie Laboratories, Niagara Falls.

Aluminium.—Like the Aluminum Co. of America (which is the new name of the Pittsburg Reduction Co.) the British Aluminium Co. is making large extensions. They have acquired a partly-developed water power at Stangfjord, in Norway, and have taken steps to develop speedily some 3,000 hp at Loch Leven. They expect to produce aluminium in Norway within about two months and at Loch Leven in Autumn. In addition, they have purchased the concessions for a water-power at Orsieres, in Switzerland. It is expected that when all these schemes are fully developed the company will have upwards of 70,000 hp. per year.

The Open-Hearth Steel Process.

Engineer Theodor Naske contributes to *Stahl und Eisen*, of Jan. 30, Feb. 6, 13 and 20, a long discussion of the reactions in this process. He starts out with the rather despairing remark, that the processes going on in the open-hearth furnace are practically uncontrollable: this would hardly be a statement which is true, but it happily turns out afterwards that the writer means that it is difficult to account for the influence of mass and temperature, and therefore hard to predict in which direction the reactions will proceed—nothing more serious than that. In the first place, the author sets out to determine how and in what way the ingredients of the charge are oxidized into the slag or reduced back therefrom into the metal.

(1) The behavior of manganese as a conveyor of oxygen. The circumstances under which this element acts as an oxidizing agent upon the bath or as a reducing agent upon the slag, are to be found in the temperature, the chemical composition of the slag, and in the concentration of the manganese in the slag and in the metal. When manganese is oxidized from the bath it goes into the slag first as MnO, forming ferrous-manganese silicate, the slag evidently striving towards the formation of uni-silicate $FeMnSiO^4$. By a comparison of thirty-two sets of analyses of metal and slag at the beginning and ending of the refining period, it was determined that whenever the manganese in the slag was less than the iron the bath lost manganese, whenever the manganese equalled the iron the bath neither lost nor gained, whenever the manganese exceeded the iron there was manganese reduced from the slag and the bath gained manganese. This was independent of the total percentage of iron and manganese in the slag, but concerned only their relative proportions towards each other. [It follows that, after the slag contains as much manganese as iron, the bath ceases losing manganese, even in an oxidizing atmosphere, and that further oxidation of manganese can only go on either as the slag receives iron oxide from oxidation of the bath (Fe and Mn would then oxidize from the bath in equal quantities), or as iron oxide is bodily added to the slag from an outside source.] Naske also draws the conclusion that a slag containing less manganese than iron not only oxidizes manganese from the bath, but usually co-exists with a bath containing dissolved FeO; that the presence of manganese equal to iron in the slag stops the solution of FeO in the bath, or even tends to remove FeO and thus purify the bath. In this respect, manganese as used systematically in the Terre Noire process, for instance, is a valuable and almost indispensable agent in the slag for preventing iron oxide being taken up in large quantities by the bath.

(2) The behavior of silicon and carbon. The silica in the slag depends on the silicon in the pig iron, that in ore additions and that from furnace lining; and the quantities of these going into the slag are the most important factors in determining the amount and quality of the slag. Carbon is more easily oxidized by artificial oxidizing agents than by free oxygen, so that there is no doubt that the carbon removed from the bath is in reality oxidized by metallic oxides. Carbon is not oxidized while silicon is present in large amount, because silicon can reduce any carbon monoxide which tends to form, producing SiO^2 and sending the carbon back into the bath. $Si + 2CO = SiO^2 + 2C$. We may assume that both carbon and silicon oxidize, but the above reaction prevents any carbon monoxide escaping. The carbon is only finally oxidized when the silicon is reduced to such proportion in the bath that, according to the law of mass action, its activity in reducing carbon monoxide is less than the speed of formation of the latter. On the other hand, it has been established that from acid slags, containing up to 55 per cent SiO^2, silicon may be reduced back into the bath at a high temperature by the carbon dissolved in the iron.

(3) The behavior of phosphorus. Two tests were carefully made to determine the action of cold ore or hot ore on pig iron to remove phosphorus. In one test 3,280 kg. of ore was dumped upon the empty hearth, 984 kg. of limestone upon it, and immediately, while these were yet cold, 20,303 kg. of pig iron run in upon them. The tests show very plainly the nature of the reaction:

	C.	*Si.*	*Mn.*	*P.*	*S.*
Metal used..	4.61	0.84	2.20	0.15	0.02
Bath in 20'..	4.50	0.19	0.45	0.05	0.01
Bath in 40'..	3.86	0.09	0.45	0.03	0.02

	Fe.	SiO^2.	*Mn*	P^2O^5.	*FeO.*	Fe^2O^3.
Slag at 20'..	41.51	17.68	15.22	2.36	47.88	6.10
Slag at 40'..	31.67	19.05	15.71	2.93	36.29	4.91

For comparison with this, 3,280 kg. of ore was charged with 820 kg. of limestone into an empty furnace, and strongly heated for 30 minutes, until it was at bright red heat but not melted. A sample taken from the furnace showed none of the ferric oxide changed to Fe^3O^4 by this heating. Upon this 19,730 kg. of fluid pig iron was run, reproducing the Monell process reaction. The reaction was very violent, and in 25 minutes showed the following changes to have taken place:

	C.	*Si.*	*Mn.*	*P.*
Metal used..	3.81	0.79	1.95	0.17
Bath in 25'..	3.62	0.09	0.31	0.02

	Fe.	SiO^2	*Mn.*	*FeO.*	Fe^2O^3.
Slag at 25'..	19.88	16.90	12.62	23.90	1.86

Still another similar test was made with 3,280 kg. of ore and 820 kg. of limestone, but these were heated until at the end of an hour they were completely melted to a homogeneous mass. A test of this showed it to be strongly magnetic and the iron mostly present as Fe^3O^4. The fluid pig iron, weighing 17,843 kg., was then run in slowly, and reacted violently, with great evolution of gas, showing the carbon to be rather strongly attacked. Test and analyses showed the following reaction:*

	C.	*Si.*	*Mn.*	*P.*
Metal used..	3.90	1.05	1.56	0.14
Bath in 15'..	3.35	0.05	0.28	0.01

The three heats just noted took respectively 4 hours 50 minutes, 4 hours, and 3 hours 10 minutes, showing the great advantage of operating according to the Monell process.

The removal of phosphorus is complicated by the fact that either carbon or carbonous oxide gas can reduce phosphorus from its compounds at a comparatively low temperature. In general, however, raising of the temperature favors removal of phosphorus from the metal; the dephosphorization is only possible in presence of iron oxide or lime in the slag; the solution of phosphoric acid in the slag adds greatly to the intensity of the reaction; an iron-lime silicate favors most the elimination of phosphorus; manganese in the bath exerts to influence upon the conditions of removal of phosphorus; the slag has a certain saturation limit for phosphoric acid, determined by its composition and the temperature, above this limit phosphorus may be reduced back into the bath.

The author is of the opinion that almost all the oxidation of elements other than carbon from the bath is effected indirectly by the carbon oxidizing first and then the gas acting upon the impurities, which latter take the oxygen and send the carbon back into the metal. In this view, Engineer Naske is certainly wrong, for his own facts and figures, closely studied, prove directly the contrary. It would be much nearer the truth, and would agree with all the facts adduced, to say that all the elements except iron are probably in largest part oxidized by the dissolved FeO, taken up by the bath, because of the overwhelming amount of iron present, and then reduced back to Fe as it oxidizes the carbon, silicon, manganese and phosphorus present. Naske makes a great deal of the application of the mass law, as largely governing the reactions in the open-hearth furnace, but has made the capital mistake of neglecting the overwhelming mass of the iron itself in the bath of metal being oxidized.

J. W. Richards.

* See calculations respecting this reaction in paper on Metallurgical Calculations by Prof. Joseph W. Richards, elsewhere in this issue.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

Platinum Substitutes.

A company with the rather suggestive title of "Platinum Substitutes, Ltd," has been registered with a capital of £50,000 in £1 shares, to acquire from C. O. Bastian and G. Calvert the benefit of certain inventions relating to sealing metallic conductors into or through glass, to turn the same to account, and to carry on the business of electricians, makers of cables, wires, fuses, accumulators and lamps, suppliers of electricity, etc.

Metallurgical Papers Read in February.

Three papers were presented to the Institution of Mining and Metallurgy for their meeting on Feb. 21. The first by Mr. W. R. Thomas on the "Electrically-Driven Centrifugal Pumping Plant at the Tywarnhaile Mine" appealed to mechanically-minded members. The second paper, by Mr. E. H. Garthwaite, discussed "Development Results versus Stope Results," and presents actual comparative diagrams and figures. In the case under examination the value of the ore was fairly uniform, and the discrepancies between the two methods of sampling were not great. The third paper, by Mr. C. F. Hughes, dealt with "Minerals and Metalliferous Lodes of Kulu and Lahol, Kangra District, Punjab, Himalayas." The chief features of Kulu are pyrrozhotite containing 15 to 20 ounces of silver per ton, and iron ore of high quality. It is pointed out that if communication were better, and a railway brought within reasonable distance, it might pay to set up an electric smelting plant to treat these ores. There is abundant water power and large forests. These ores have been smelted by the natives in small charcoal furnaces for several centuries. As regards Lahool, gold is extracted in very paying quantities by the natives from the sands of the Chandra River. A massive lode of pure stibnite 15 feet thick was reported some years ago. In view of the present scarcity of antimony it might be worth while to give more attention to this subject.

The Faraday Society.

It was unfortunate that the meeting on Feb. 19, to which Mr. J. B. C. Kershaw presented a paper upon the "Electrolytic Bleach and Alkali Industries" was somewhat sparsely attended. The discussion, however, occupied the whole evening; the chief features were the reminiscences of the early days of the industry contributed by Mr. Rhodin and by Mr. Richardson. The former, in particular, threw much light upon the evolution of the mercury cathode, and amused the audience by one or two rather pertinent asides aimed at the dissociation and other theories. Speaking on the subject of the voltage required for such processes, the observation was made that "if you were a plain, practical man, you found it to be four volts, but if you were a theorist you called it anything you liked." As to the fetters which restricted the development of such industries, they had to remember the evils of over capitalization. It was no good expecting to get rich in a few weeks as some speculative company promoters had anticipated, a successful industry required a slow and steady development. Then, too, inventors had been too optimistic—they had miscalculated capital requirements, and miscalculated wear and tear. Lastly, further extensions were hampered by the exorbitant value put upon waterfalls by their owners.

Mr. Richardson, speaking also in the reminiscent vein, gave a new version as an actual participator in the Richardson-Holland process.

A large number of questions were aimed at the author by the other speakers, who included Dr. Borns, Dr. Perkin, Dr. Seligman, Mr. Gaster and Mr. Digby. Some questioned points in the paper, but more asked for information concerning the merits of different makes of graphite and carbon, such as life and working current density, the life and material used for diaphragms in diaphragm processes, and so forth. The general feeling was that of regret at the extreme reticence of the manufacturers who had declined to give particulars of practical or any interest, leaving the author to base the greater part of his paper upon patent specifications. Upon the motion of Dr. Lowry, who presided, a vote of thanks was unanimously passed to Mr. Kershaw, who deferred his reply to the transactions of the Society.

Market Prices.

The end of February finds the iron market depressed and wanting in tone. The collapse of the "bull" movement has emphasized the steady fall in Cleveland warrants, which are standing at 54.6. Steel rails are fairly steady at £6.15, and plates £7.10. per ton. Copper is still tending to go higher and occupies a firm position at £108. It does not seem probable that the supply will approach the demand for some months. Lead is again lower at £19.17 to £20 per ton. Tin has been lower, rallying to £193. Zinc is quoted at £30.15 per ton. Platinum remains at £7.10. per ounce. Shellac still at £11 per cwt. Para rubber is steady at 5.1. to 5.1½. per pound. Copper sulphate is quoted £32.10 per ton, no alteration on last month.

London, March 5, 1907.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Nickel Silicide and Ferronickel Silicide from Sulphide and Silicates.—Thomas L. Willson, 847,267 and 847,300. March 12, 1907. Application filed April 11, 1904.

Mr. Willson, whose pioneer work in the calcium carbide industry is so well known, applies in these patents his carbide arc furnace to the problem of treating sulphides or silicates of nickel, iron or copper for the production of silicides of these metals, either singly or alloyed. The process consists simply in smelting a mixture of the ore, lime, silica and carbon in an electric furnace. Practical applications are the treatment of the worthless form of iron silicate of sulphur, which is now a waste product in the reduction of nickel-sulphide ores; also the treatment of nickel and iron sulphide ores, which contain usually a small proportion of copper. If a mixture of the latter ore with limestone, silica and carbon were smelted in a blast furnace, there would result a calcium silicate of iron and a nickel-copper matte. But by the more active reduction obtainable by electric smelting calcium and silicon are freed, the calcium uniting with the sulphur of the ore and forming calcium sulphide, which floats off and the silicon uniting with the nickel and iron, forming a ferro-nickel silicide. Some of the silicon also combines with the sulphur to form silicon sulphide, which is volatile. To calculate the charge, one may proceed as follows: Enough lime is to be added, calculated to CaS, to combine with the total sulphur in the ore. Enough silica is to be added to form with the calcium equivalent thus determined $CaO(SiO_2)_2$. Then enough carbon is added to liberate from the calcium silicate the calcium and silicon, the former uniting with the sulphur and the latter with the iron and nickel. In practice, however, very much less lime, silica and carbon—perhaps only half the theoretical amounts found in the above manner—are sufficient. This is explained by the intense heat "dissociating sulphur, which is volatilized and

driven off and could doubtless be recovered as a by product."

The following figures are given for the treatment of a ferro-nickel sulphide ore, containing 44 to 48 percent of iron, 4 to 7 nickel, 1 to 2 copper, 26 to 28 sulphur, 14 to 22 insoluble (diorite). To 300 pounds of this ore, suitably crushed, add 120 pounds of crushed limestone, 98 pounds of sand, and 107 pounds of granulated coke. This mixture is treated in an electric furnace, just like for the production of calcium carbide. Energizing the furnace with 35 to 37 volts and 4,000 amperes, the reduction of this quantity of material will require from 2 to 3 hours if started cold. The resulting ferro-nickel silicide has analyzed as follows: 75.0 per cent iron, 9.4 nickel, 12.46 silicon, 0.035 sulphur, 0.70 copper, 1.145 unascertained impurities. In running continuously, the calcium sulphide remains in the furnace when the silicide is tapped off, so that the quantity of lime or limestone used may be greatly diminished after the first few hours, the proportion of sand being correspondingly increased, thereby cheapening the process. For the more complete elimination of the sulphur the heat of the electric furnace may be increased, or the proportion of silica may be increased or fluorspar may be added, shortly before tapping off the product, introducing it preferably with a blast of air through tuyeres.

The process is also applicable to the treatment of silicates of iron, nickel and magnesium, such as those known as "New Caledonian" ores. In this case no silica need generally be added. The proportion of lime required may be diminished according to the proportions of magnesium contained in the ore. In the case of an ore containing an exceptionally large proportion of magnesium, due to its containing little or no free silica, the proportion of lime required may be reduced to the minimum. The proportion of carbon required is that which is required to combine with the oxygen compounds comprised in the ores.

The ferro-nickel silicide produced in this process is chiefly useful in the production of nickel steel. For this purpose iron is added to reduce the nickel to the desired proportion, which may be done either in the electric furnace or in a subsequent process, after which the silicon is eliminated by bessemerizing.

Production of Silicides and Silicon Alloys.—F. J. Tone, 842,273. Jan. 29, 1907. Application filed Dec. 16, 1905.

This patent reports further progress of the work of Mr. F. J. Tone, of the Carborundum Co. on the production of metallic silicon and silicon alloys. If, in the manufacture of silicides, for instance, manganese silicide, a charge of silica, manganese dioxide and carbon is heated in the electric arc furnace, an alloy or compound of silicon and manganese is obtained, but with a large loss of both silicon and manganese by evaporation. The inventor now states that this loss can be prevented by using an electric resistance furnace, with a molten bath forming the resistor and comprising the ore, metallic compound or metal with a reducing agent and solvent or flux, such as lime or fluorspar. For instance, when manganese and silicon are to be combined the charge is made up of 38 per cent of silica, 24 manganese dioxide, 21 carbon and 17 lime. This is heated in the crucible as shown in Fig. 1. The lower ends of the electrodes are immersed in the bath and the heat produced in it is sufficient to accomplish the reaction whereby the metal or alloy settles in the bottom of the receptacle as the layer 10, with the slag 9 overlying the metal. If metallic silicon is to be produced the charge consists of

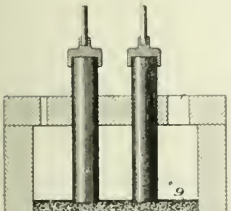


FIG. 1.—TONE ELECTRIC FURNACE.

silicious ore with a reducing agent and flux. The metal, which is to be alloyed with the silicon, may, of course, be introduced into the charge as metal and not as oxide; for example, a silicide of iron and manganese may be obtained from a charge of ferro-manganese, silica, carbon and flux.

Electric Furnace.—B. von Ischewsky, 847,003, March 12, 1907. Application filed Feb. 15, 1906.

The right-hand diagram is a vertical longitudinal section, and the left-hand diagram a vertical transverse section. The furnace chamber, containing the molten metal 2 is in form of a revolving drum lined with electric conductors of the second class, that is, such materials which do not conduct the current at ordinary temperature, but become conductors at high temperatures. The lining may be almost the same as in ordinary open-hearth furnaces or converters, being made of oxides, preferably magnesia, calcium oxide and other oxides, either basic or acid oxides. The carbon rods 3 are introduced radially from the outside through the walls of the drum, so as to just touch the oxide lining. These carbon rods can be pushed inwardly when they are burned away. They are con-

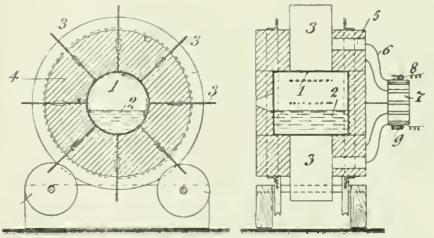


FIG. 2.—ISCHEWSKY ELECTRIC FURNACE.

nected by lateral pieces 5 to conductors 6 with the commutator 7, against which bear two brushes 8 and 9 through which the current is supplied. To start the furnace, hot slag or other hot material is introduced into the drum and the furnace then revolved somewhat, so that the inner layer is heated up to such an extent as to become electrically conductive. When the current is then switched on it passes from the carbon rods through the furnace lining. The curves of the current are denoted by the arrows in the left-hand diagram. Under all circumstances it is necessary that at least one electrode be outside of the metallic bath 2, so that the current is compelled to pass along the lining of the furnace. As special advantages of this design it is stated that the furnace can be operated directly by high-voltage currents. There are no carbon electrodes in contact with the charge; and when using consecutively electric furnaces with acid or basic linings any desired reactions for refining may be obtained.

Electric Furnace.—Le Roy Wright Stevens, 846,521, March 12, 1907. Application filed Sept. 16, 1905.

Details of mechanical construction of the mechanism by means of which a movable electrode is introduced through a furnace wall, so as to keep the furnace air-tight. The first claim relates to "the combination with the furnace body and the electrode of a stuffing box, a movable sleeve mounted in the stuffing-box and surrounding the electrode, and providing a space between the inner wall of the sleeve and the electrode, granular refractory material in said space, means for retaining the granular material in position in the sleeve, and means for connecting the sleeve to the electrode." By means of water cooling the mechanism is protected against the heat of the furnace.

Production of Carbon Electrodes.—T. P. Shorts, 845,585, Feb. 26, 1907. Application filed March 6, 1905.

The object is to produce homogeneous carbon electrodes which are good conductors and at the same time withstand high temperatures. The nozzle of a burner extends through one

end wall of the furnace and hydrocarbon oils (petroleum) are burned under the influence of a blast of air under sufficient pressure so as to carry the atomized jet of mixed air and oil across the furnace chamber. The products of combustion are deposited on the opposite end wall of the furnace chamber, and to thicken the deposit this end wall is gradually removed to further distances from the burner. When the "charcoal-carbon" deposit is sufficiently thick, the wall is removed and the deposit is taken off and shaped into the desired form by cutting, grinding or otherwise. The product is said to be very hard and specially suitable for arc-furnace electrodes.

Electrolytic Processes.

Electrolytic Production of White Lead.—C. P. Townsend, 847,032 and 846,526, March 12, 1907. Application filed April 18, 1902. Patent 846,526 refers to the apparatus, 847,032 to the process.

In former attempts to electrolytically produce white lead it has been found that the product is irregular in composition and quality and deficient in covering power. These disadvantages may be overcome according to the inventor if a definite circulation of the electrolyte is produced successively past the respective electrodes and preferably in the direction from the anode past or through the cathode. Fig. 3 shows one type of apparatus. B is the anode which consists of lead, while the perforated plates C constitute the cathode. They may consist of perforated metal or of wire gauze. The electrolyte—which is a mixture of sodium nitrate or acetate with sodium carbonate in the approximate proportion of 10 to 1—passes through the apparatus along the paths indicated by the arrows. From the lateral channels *gg* the electrolyte enters into the outlets D and then passes through the pipe G into the filter press H. The filtered electrolyte flows into tank I, and is then raised again by means of the fan M into the electrolytic vat. The circulation is, of course, not confined to the electrolyte alone, but the pigment or insoluble anodic product detaches

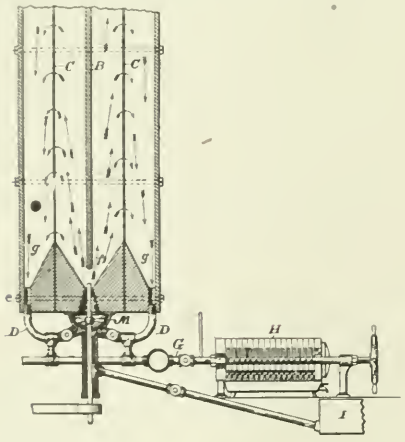


FIG. 3.—ELECTROLYTIC PRODUCTION OF WHITE LEAD.

itself from the anode B and is carried upwardly with the electrolyte through the cathode and then to the filter press. The area of the cathode is much smaller than that of the anode. "This is of great assistance in preventing the formation of lead sponge by reduction of the pigment, not only because the speed of circulation through the cathode is thereby increased and the pigment prevented from adhering to it, but because the electrolytic reduction itself proceeds more slowly when the cathode area is relatively small and the current density at the cathode is relatively high." The best current density depends to some extent on the speed of circulation of the electrolyte. With a higher current density a more rapid circulation may be employed. To regenerate the electrolyte it is, of course, necessary to add continuously or at intervals carbon dioxide and water in quantity equal to that removed by the pigment. The carbon dioxide may be made use of for effecting better circulation.

Reduction of Metallic Sulphides.—Edward L. Anderson, 846,642, March 12, 1907. Application filed Dec. 26,6 1905.

The object is the cathodic reduction of metals from their sulphides with the simultaneous development of hydrogen

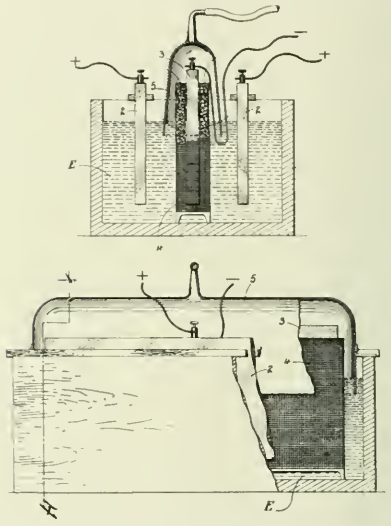


FIG. 4.—CATHODIC REDUCTION OF SULPHIDES.

sulphide. In its general scheme the process is, therefore, similar to the Salom lead reduction process (our Vol. I., p. 18). The upper diagram in Fig. 4 shows a vertical transverse section of the reduction tank, and the lower diagram is a part side elevation and part section of the same; 2 and 2 are carbon or graphite anodes, while the carbon or graphite plate 3 represents the cathode, which is surrounded by a wire basket 4 suitably laced or enameled, so as not to be effected by the electrolyte E, which is silico-hydrofluoric (hydrofluosilicic) acid, H_2SiF_6. By means of the bell 5 the H_2S gas is carried off to be burned in gas engines driving electric generators. For instance, to get zinc from zinc sulphide the ore is ground to about 15 or 20-mesh, and filled into the basket 4 around the cathode. The cathodic action is the formation of H_2S gas, which is carried off, while simultaneously the metallic zinc reduced from the sulphide goes into solution as $ZnSiF_6$. From this solution the zinc is then at once deposited on the cathode.

Insulating Diaphragm for Cells with Molten Electrolytes.—G. O. Seward and F. von Kuegelen, 842,256, Jan. 29, 1907. Application filed July 17, 1905.

It has formerly been proposed to form a non-conductive diaphragm or partition within a molten electrolyte by using simply a water-cooled iron partition. It was supposed that the layer of chilled salt which then forms on the surface of the iron curtain would prevent the current to pass through. It is, however, not possible to maintain such a layer of chilled electrolyte in sufficient thickness and at a sufficiently low temperature to avoid its conducting a portion of the current from the electrolyte to the curtain. The curtain will then act as an intermediate electrolyte and become inefficient as a diaphragm. To prevent this, the present inventors use two such water-cooled curtains whereby they are enabled to get a

sufficiently thick mass of electrolyte between the two curtains to act as insulating diaphragm. The construction is shown in Fig. 5. D is the cathode and A the anode. Between the

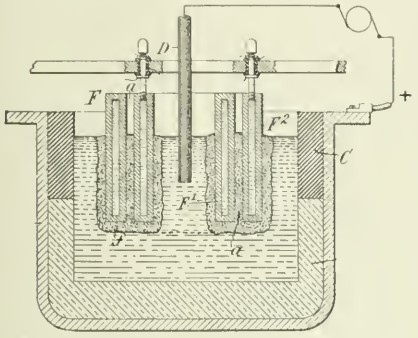


FIG. 5.—DIAPHRAGM CELL FOR MOLTEN ELECTROLYTES.

anode and cathode is introduced the non-conductive partition F, which is made of two tubular cylindrical water-cooled curtains F′ and F², the former being arranged concentrically within the latter, leaving an annular space *a* of uniform width between them. The curtains F′ F² may be made of cast iron cored out to form a water space or channel through which a circulation of water is maintained to cool them. The two curtains are necessarily insulated from one another. By the circulation of the water the hollow curtains are so cooled that the layer of molten salt is congealed upon them and the space *a* between the two curtains is filled up with congealed salt.

Precipitation of Gold from Cyanide.—W. A. Hendryx, 834,575, Oct. 30, 1906. Application filed Jan. 17, 1906.

Mr. Hendryx' work in the cyanide process has been repeatedly noticed in these columns, for instance, our Vol. IV., p. 504. The present patent relates to the construction of "precipitating cells." Such a cell consists of a rectangular wooden frame, the exterior of which is covered by a filtering canvas sack, while the inside contains graphite anodes and copper, tin or iron cathodes. A number of such precipitating cells are placed in an extraction tank and submerged in the body of ore-pulp of metal-bearing cyanide solution contained therein. The interiors of the precipitating cells are connected with the suction-line of a pump, whereby the solution is carried into the cells, while the suspended matter is retained outside by means of the filter cloth. The gold is electrolytically deposited on the cathodes. At suitable intervals the pulp or slime adhering to the outside of the filtering canvas is detached by forcing air into the inside of the cells.

Electroplating Apparatus.—D. F. Broderick, 830,719, Dec. 25, 1906. Application filed July 27, 1906.

Mechanical details of construction of dipping mechanism, whereby the articles to be plated and carried by a work-holder, are automatically dipped successively into the various plating and washing baths. An endless carrier is provided for the work-holders and so associated "with a series of tanks and work-holder-elevating devices that the endless carrier can be utilized throughout its full extent of travel for moving the work-holders and causing the successive immersing of the work or articles to be plated into baths arranged under the carrier, whereby the complete process of plating and washing can be accomplished while the article carried by a holder is moving from a given starting point until it returns to such starting point."

Recovery of Metals from Fumes.—L. Dion, 840,480, Jan. 8, 1907. Application filed March 4, 1904.

The inventor claims he can concentrate and recover metals contained in the fumes and vapors arising from molten metal and can simultaneously segregate them from one another by the following method. The fumes are first subjected to the action of an electric current supplied through appropriate electrodes in a dry chamber, whereby particles of metals are concentrated. The fumes, with the particles thus concentrated, are then subjected to the action of an electric current in a liquid bath, "by which means not only are the particles or masses already precipitated by the action of the electric current in the dry chamber aggregated into larger masses, but any particles of metal remaining to the fumes, gases, or vapors after passing through that chamber also precipitated and recovered."

Batteries.

Metal for Storage Battery Grids.—W. Morrison, 842,801, Jan. 29. Application filed Jan. 20, 1905.

To make a strong solid grid, free from pores, the inventor uses a lead-antimony-phosphorus alloy. To prepare this, he mixes an alloy of 100 pounds of lead and 12 pounds of antimony, while in molten condition, with 2 ounces of phosphorus. "The phosphorus must be added in small portions first after the molten metal is stirred and then the air-tight cover of the pot is put on." This is repeated until the desired amount is added. Two other methods are also described.

Storage Battery.—S. Lake, 844,815, Feb. 19, 1907. Application filed May 26, 1904.

In storage batteries of large capacities it is important to have the walls of the cells stiff enough to prevent them from bulging outwardly into contact with those of the adjacent cells; to insure against leakage of electrolyte from any cause and thus avoid liability to short-circuiting. How the inventor endeavors to attain this end is indicated by the first claim: "A battery cell comprising an inner tank and an outer tank inclosing the same, rigid plates of material infusible at moderate temperatures interposed between and spaced from the walls of said tanks, and a filling of readily-fusible waterproof insulating material also interposed between the walls of said tanks and occupying the spaces intermediate said plates and the walls of said tanks."

Storage Battery Plate.—Joseph Bijur, 845,048, Feb. 26, 1907. Application filed Aug. 14, 1906. (Assigned to General Storage Battery Co.)

Details of construction of a paneled plate, the features of which will become clear from the description of a single panel. Within its rectangular frame are placed horizontally a large number of alternately straight, flat strips and of corrugated strips so as to fill the whole interior of the frame. The surfaces of both the straight and the corrugated strips form the active surface which is therefore large. To keep all these strips in proper position, they are provided with holes, and rods are cast through these holes from the frame.

Negative Plate.—Joseph Bijur, 845,391, Feb. 26, 1907. Application filed April 8, 1906. (Assigned to General Storage Battery Co.)

In the long series of storage battery patents of Mr. Joseph Bijur, president of the General Storage Battery Co., of New York, with works at Boonton, N. J., this patent is a particularly important one, since it solves the old difficulty of the loss of capacity in negatives, which has been the bane of manufacturers in the past. It is reported that this method has been practiced by the General Storage Battery Co. for over a year with full success. The loss of capacity in the plate is prevented by impregnating the plate with an inert material, not chemically acted upon by the electrolyte, like carbon. A peculiar and important feature is that the plates are impregnated after they have been formed, so that the process is applicable to plates which have been in use. The process is applicable to Plante plates and pasted plates. In the case of Plante plates the plate is first formed and reduced to a spongy lead in the

usual manner and allowed to dry. It is then soaked for about 10 minutes in a solution of sugar of about 2 to 30 per cent. The solution penetrates readily the pores of the plate at ordinary temperatures. The solution is then rinsed from the surface of the plate and the plate is dried by permitting it to stand in air. If the plate is all pure lead, it is then baked in any suitable apparatus at a temperature of from 240° to 300° C. for 5 or 10 minutes, until the sugar is completely carbonized. If the plate has alloy parts, as, for instance, an antimonious lead frame (with a lower melting point than pure lead), the plate is heated in such a manner that the frame is subjected to less heat than the grills. There is, of course, no difficulty in doing this, and a suitable heating apparatus is described in the patent. In the case of pasted plates, the finished dried negative plate is placed in the sugar solution for about 10 minutes. It is then taken out, dried in air and heated in the same way as in the case of the Plante plate, whereby the organic material in the pores is again carbonized. The carbon may thus be introduced into the pores of the active mass of pasted plates even after they have been in use and have partially lost their capacity from the lack of such material, thereby again raising the capacity of the plate. "The invention also contemplates soaking a Plante or pasted plate in a solution of suitable material—as, for instance, sodium silicate—in which case the inactive material is deposited in the pores of the active mass in the plate chemically instead of by drying and carbonization." Plante plates treated by this process have a light brownish-gray color instead of the usual lead-gray color of the Plante plate. They have a very porous and spongy appearance, as distinguished from ordinary Plante plates, not treated by this process. In use the capacity of the plate either remains substantially the same or rises instead of falling off.

Battery Jar.—J. Y. Bradbury, 842,016, Jan. 29, 1907. Application filed Oct. 25, 1906.

To get a battery jar which can be handled roughly without danger, he uses a cell of hard rubber and provides it with a jacket of flexible fibrous material, such as cloth which is rendered impervious to liquids and is acid and alkali-proof. This external armor covers the bottom and the greater portion of the sides and ends of the cell, but leaves the upper portion of the cell uncovered so that when a number of armored cells are placed in a retaining box, an air space is formed between the upper ends of the contiguous cells. The object is to prevent leakage from one cell to the next, due to moisture.

Storage Battery Switch.—S. A. Leonard, 842,405, Jan. 29, 1907. Application filed May 14, 1906.

Mechanical details of construction of switches for storage batteries. The first claim reads: "In switches for storage batteries a suitable supporting frame, longitudinally movable plates mounted oppositely on said frame, and brush and plate connections for the current operatively related to said plates."

Primary Battery.—F. J. Decker, 842,389, Jan. 29, 1907. Application filed Feb. 27, 1904.

This is another patent relating to the Decker battery (our Vol. IV., p. 441, and our Vol. V., p. 58 and 104). The first claim relates to "a battery comprising a plurality of cells, a duct extending into the interior of each of said cells, a conduit communicating with a plurality of said ducts, and means for connecting said conduit to said ducts, said connection permitting the removal of said cells and ducts without moving said conduit."

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

Industrial Electrochemistry.

Electrolytic Precipitation of Gold from Cyanide Solutions.—In our Vol. II., pp. 55, 131 and 215, we gave detailed information on the Siemens-Halske electrolytic process for precipitating gold from cyanide, as operated in South Africa and America, and on modifications of this process due to Mr. Charles Butters. In a note by Mr. Butters in our Vol. II., p. 207, he then brought out that in his plants he now uses a combined zinc and electrolytic precipitation process. An interesting article by Mr. Charles B. Richmond, in the *Engineering and Mining Journal* of March 16, describes the process as it is now operated at the (Butters) San Sebastian Mine in San Salvador. Very small amounts of silver are present in the ore, which is a complex mixture of sulphides. Free gold, in the unoxidized zone, is of common occurrence, but the greater part is combined with the telluride and sulphide. The quantity of copper varies. The cycle of the ore from the time it reaches the mill is as follows: Breaking in Blake-Marsden crushers, drying in rotary dryer crushing in ball mills to 40-mesh, roasting in Jackling furnaces, whereby the sulphur is reduced from 3.5 to 0.5 per cent; elevation of the roasted ore with weak cyanide solution to sand collecting tanks, separation of sand and slime, agitation and filter box treatment for slime, gravity percolation for sand, recovery of gold and copper by means of combined electrical and zinc precipitation. The gold extraction has averaged 95 per cent during the period of operation, about four years, and the only drawback was that the product contained gold and copper precipitated on lead foil cathodes. Cupellation refining was impossible because of the large excess of copper, hence these cathodes were milled, sampled and sent to the smelters.

The average composition of the product was 3.37 per cent of gold, 65 per cent of copper, the remainder being lead. The smelters paid nothing for the copper and lead, and only 32s. 6d. per fine ounce for the gold. Tinned iron cathodes had been tried at this plant, but were discarded in favor of lead, for two reasons: first, because of the excessive quantity of gold necessary to coat the plates before any values would slime to the bottom; and, second, because of the difficulty and the loss in scraping off the dense hard deposit of gold and copper. The present author has now devised a process by which the gold, copper and lead are sufficiently separated to bring their respective values. The lead cathodes are returned to the precipitation boxes. The copper is shipped to the smelters as copper cement, and the gold precipitated is melted into bars, which are shipped to the refiners, and realize 84s. 11½d. per fine ounce, less a charge of 2d. per bullion ounce for refining.

The cyanide solutions first enter the electric precipitation box containing anodes of peroxidized lead plates ⅛ inch thick, and lead cathodes of 1/16 inch thick. The anodic current density is 1 amp. per square foot. The gold and copper precipitated on the cathodes form dense hard coatings. There is no tendency to slime. However, there is a gradual accumulation of low-grade precipitate on the anodes and on the bottom of the box with the gold content of from 5 to 50 ounces per ton. From the electric precipitation box the solution flows into the zinc boxes. The electric section extracts from 80 to 90 per cent of the gold, nearly all the copper that is precipitated, and re-

generates a high percentage of the cyanide. The tail solution from the zinc carries from 0.06 to 0.10 dwt. per ton, giving a total extraction of about 99.5 per cent. The special new feature is the treatment of the lead cathodes with their dense gold and copper deposit from the electric precipitation boxes. They are treated as anodes in acid boxes containing dilute (2 to 3 per cent) sulphuric acid. They hang in a wooden frame with closed bottom and open sides; over each is stretched a cotton cloth sack. The cathodes are lead plates. As the result of electrolysis the copper on the now anode plates dissolves, passes through the cloth of the frame and precipitates on the cathodes, where it slimes and falls to the bottom of the box. The gold released from the copper falls to the bottom of the anode frame. In this way the gold and copper are obtained separately, while the lead plates are brought back to their original condition and are used over again as cathodes in the cyanide precipitation box.

Electrolytic Rectifier.—*L'Industrie Electrique*, of Feb. 25, contains a note on a paper by de Faria, presented before the (French) Physical Society, on his electrolytic rectifier, which does not differ in principle from the old type. The special feature seems to be an automatic regulation of the electrolyte, which prevents the temperature from rising to a dangerous value. The electrodes consist of pure commercial aluminium and antimonial lead, and the electrolyte is a solution of sodium phosphate.

Electroplating.—In the February issue of the *Journal* of Société Belge d'Elec. and in the issue of Feb. 25 of *L'Industrie Electrique*, R. Goldschmidt describes a useful method of electroplating large articles which cannot be conveniently placed in an electrolytic tank. He soaks an ordinary brush with the electrolyte and connects it with the positive pole by means of a wire of the metal to be deposited wound around the top of the brush. The article to be electroplated is made the negative pole. When the article is touched with the brush the circuit is closed and the metal is deposited on the article. With a 110-volt supply circuit he uses in series with the brush six lamps of 50 c.p., which represent a resistance of about 750 ohms. The current thus obtained is about 1/10 amp. The following solutions are recommended: For silver plating, use 20 grams of silver nitrate, 30 grams of potassium cyanide, 0.4 gram of ammonia (95 per cent), 2 grams of potassium formate, and add water to get one liter of solution. For gold plating use 6 grams of gold chloride, 2 grams of ammonia (96 per cent), 13 grams of potassium cyanide and add water to get one liter solution; finally add 2 grams of potassium formate. For copper plating use 180 grams copper sulphate, 60 grams concentrated sulphuric acid and add water to get one liter of solution; then add 10 grams of alcohol (96 per cent). For nickel plating use 60 grams of nickel sulphate, 20 grams of sodium sulphate, 20 grams of sodium citrate and add water to get one liter of solution. For nickel plating it is preferable to use only a low tension, 2 or 4 volts.

Fuels.

Coal.—Goutal, in the *Journal für Gasbeleuchtung*, 1905, Vol 48, p. 1,007, has given a reasonable solution of the very interesting question of calculating the calorific power of a coal directly from its proximate analysis,—fixed carbon, volatile matter, water, ash. The percentage of volatile matter is to be recalculated in per cent of the weight of fixed carbon plus volatile matter (pure fuel), and then the calorific power calculated by giving the fixed carbon present in the fuel a calorific power of 8,200, and the volatile matter present a calorific power which varies with the calculated per cent of volatile matter in the pure fuel, as follows: (Multiply figure given by 100.)

Per cent volatile matter.....	5	6	7	8	9	10	11	12	13	
Calorific power (÷ 100).....	145	147	139	136	133	130	127	124	122	
Per cent volatile matter.....	14	15	16	17	18	19	20	21	22	
Calorific power (÷ 100).....	120	117	115	113	112	110	109	108	107	
Per cent volatile matter.....	23	24	25	26	27	28	29	30	31	
Calorific power (÷ 100).....	105	104	103	102	101	100	99	98	97	
Per cent volatile matter.....	32	33	34	35	36	37	38	39	40	
Calorific power (÷ 100).....	97	96	95	94	91	88	85	82	80	

Example: A coal contained 86.70 per cent fixed carbon, and 10.05 per cent volatile combustible matter (besides 1.45 per cent ash and 1.80 per cent H_2O). It contained, therefore, 96.75 per cent of pure fuel, of which $10.05 \div 96.75 = 0.104 =$ 10.4 per cent is volatile matter.

The calorific power of the volatile matter corresponding to 10.4 per cent in the coal is therefore, from the table $129 \times 100 = 12{,}900$ Calories. The calorific power of the coal is therefore:

		Cal.
Carbon	$0.8670 \times 8{,}200 =$	....
Vol. matter	$0.1005 \times 12{,}900 =$	....
	Sum =	8,406
Direct experiment		8,404

It is stated that the calculation is within 1 per cent of the values obtained calorimetrically. It should be noted that these values are the higher ones, for coal burned to vapor of water condensed, and that a correction of 50 to 350 Calories would be needed to get the lower or practical calorific power.

Utilization of Peat.—The *Elek. Zeitschrift* of March 7 contains an interesting review of the attempts which have been made to utilize the extended deposits of peat in Germany. In view of the absence of large water powers this problem is of special interest to Germany, but may become of industrial importance also in this country. The peat industry has really lost ground somewhat in Germany during the last ten or twenty years. Of the methods for coking peat that of Ziegler has been found most successful. It yields a very strong and pure coke and, as byproducts, a certain proportion of the nitrogen in the peat in form of ammonia and several other valuable products of dry distillation. But although the Ziegler process has been technically as well as financially successful on the Upper Bavarian coke works in Bauerberg, it would not seem to be suitable for very large plants. The writer believes that a really rational utilization of peat on a large scale is possible only by perfect gasification of the fuel in large gas producers in connection with large gas engines driving electric generators. Prof. Frank (of cyanamide fame) has recently delivered a lecture on the use of blast furnace and coke oven gases for the operation of gas engines. Up to April 1, 1906, there were in German mines and metallurgical works 391 gas engine plants, with a total capacity of 416,000 hp., the largest capacity of a single gas engine being 5,000 hp. Reference is then made to the well-known Mond process, which yields producer gas and ammonium sulphate as a by-product. Caro has improved this process in so far as he gasifies poor fuel in a mixture of air and over-heated steam. Extended experiments with this modified process on the Mond works in Stockton have shown that it is possible to treat directly wet peat, containing 50 to 55 per cent of water, with a simultaneous increase of output of ammonium sulphate. On the bituminous coal mine "Mont Cenis," near Herne, in Germany, a new large gas producer plant is to be erected in which the new process is to be used for treating waste coal and peat. The chief result of the success of this first large undertaking would be to render available the use of wet non-briquetted peat in gas producers, while the ammonium sulphate obtained as a by-product will assure in itself a fair interest on the capital invested. The latter is $187,500.

Gold.

Loss of Gold in Placer Mining.—Mr. Dennis Storall, in *Min. and Scientific Press*, Feb. 23, calls attention to the fact that in order to catch as much as possible of the gold and platinum in placer mining operations, the slime boxes must be provided with more efficient riffles than those that are used generally. He maintains that the riffle which saves the greatest percentage is the riffle that offers the least resistance, but which allows the gold and the platinum sand ample chance to settle. The block riffle, which is used extensively and consists of 5 or

6-inch blocks sawed, squared and set in pairs on the sluice floor, the blocks being cut and set with the lower side higher than the upper, so as to increase agitation and resistance, is a "boiling" riffle of the worst kind. About half the gold and all the platinum, kept constantly on the surface of the current by the agitation of the water, fails to settle and flows over the dump. An efficient riffle is made of railroad rails placed bottom-side up, tilted just a little and set an inch or more apart on the sluice floor. Such a riffle gives the gold ample opportunity to settle in the crevices between the rails. According to the author a cheaper and more easily handled riffle is made by setting 2 x 4-inch scantlings edgewise on the sluice floor and 2 inches apart. The top edge is slightly leveled and strap iron is bolted on it, the straps being half an inch wider than the scantling. This riffle does not produce agitation, and the gold and platinum sand settle in the crevices between the scantling. Such riffles, cleated together and made of a width and length to fit each sluice section, can be readily set in the boxes and easily lifted out and raised at clean-up time.

Cyanidation of Raw Pyritic Concentrates.—The ore of the mines of the Socorro Gold Co., Yuma County, Arizona, consists of quartz with pyrite as the principal mineralizer, with occasional galena and corellite. It is treated in a 20-stamp mill. No provision was made to treat the concentrates, and they could not be shipped on account of the high freight and smelter charges. Attempts were therefore made to cyanide them raw locally, and the practice finally adopted is described by Mr. F. Smith in the *Bi-Monthly Bulletin* of the Am. Inst. of Mining Engineers, January. In laboratory experiments it was found that if the concentrates were ground to 100-mesh and agitated with cyanide for 32 hours, about 85 per cent of the gold and 70 per cent of the silver could be extracted, with an expense of about 6.5 pounds of cyanide per ton. The mill practice, however, has given much beter results. The yield of concentrates in the mill is about 2 tons per day. The treatment is carried out in a 5-foot old-style amalgamating pan with wooden sides. The pan is charged with about 1 ton of solution, carrying 6 pounds of cyanide, 6 pounds of lime and 1.5 tons of raw concentrates. The pan runs at about 75 r. p. m., and grinding is continued for 8½ hours, about 2 pounds more of cyanide being added during the day as the strength fails. At the close of the grinding the temperature of the mass has risen about 40° F. above the outside temperature, a fact to which the author attributes the better extraction of the values in mill practice as compared with laboratory results. When the grinding is finished the material is discharged into one of two 15-ton leaching tanks. When a charge from the grinder has been put into the leaching tank and the solution has settled to some extent the material in the tank is covered with dry middlings from the table in order to facilitate percolation. When a leaching tank is filled it is continuously leached with cyanide solution, while the other tank is being filled, and one tank receives about four days of extra leaching after it is filled and three days washing before discharge. The average extraction in a six months' run has been about 94 per cent of the total values; the whole plant is operated, without extra cost, by the man who attends the tables and vanners. The total cyanide consumption is about 8 pounds per ton. The total cost of treating the concentrates, including the values left in the tailings, does not materially exceed $5.00 per ton.

Grinding in Tube Mills at the Waihi Gold Mine, Waihi, New Zealand.—The Waihi mine, the largest in New Zealand, was one of the pioneers in the introduction of the tube mills into its metallurgical practice, and has found them so effective that it has been decided to equip the Victoria mill of 200 stamps with a plant of at least nine tube mills. The Waihi mill has three mills of the Davidsen 22-foot type, running at 27.5 r. p. m. and carrying a load of 5.5 tons of flints. The quantity of the later consumed per week is 18 cwt. As in every mill where tube mills are installed, experiments have been conducted with various kinds of linings. The lining now adopted is the so-called "honeycomb" lining of H. P. Barry, the construction of which has been described in the Synoposis. As used at the Waihi plant, it consists of a light cast iron frame, 22 x 14 x 3 inches deep, shaped to the curve of the mill and divided into four or six compartments by thin walls. A temporary sheet iron back is fastened to the frame, and each compartment is then firmly packed with rough lumps of hard quartz or quartzite, varying in size up to 4 inches square. These lumps are bedded in with a mixture of Portland cement, coarse and fine sand. The linings thus formed are allowed to set for several weeks, preferably under exhaust steam, the longer the better, before they are being placed in the mill. This method of lining the mill requires a much shorter stoppage for relining than was necessary when the lining was made with quartzite blocks. The frames fit neatly with each other and with the shell of the mill, and, therefore, only a small quantity of cementing material is required. The grinding efficiency is stated to be quite equal to that of the quartzite blocks and the lining, including labor, costs about $175, as compared with $400 for lining with quartzite blocks. The author states that in addition to the benefits of an increased tonnage, due to the substitution of a 20-mesh screen in place of a 40-mesh in the batteries, the tube mills have favorably influenced the extraction, as before their use the combined sand and slime residues assayed 31 grains of gold per ton, or an extraction of 89.8 per cent, whereas with the tube mill plant the combined residues assay 24 grains of gold per ton, representing an extraction of over 92 per cent. The effect on the slimes treatment has also been very beneficial, as a large proportion of sand is ground so fine by the mills that it passes the spitzlutte with the slimes, and thus makes the latter more easily treatable either by the filter presses or the vacuum process. The cost of running the tube mills per ton of sand passed through is as follows: Power, 12.5 cents; flints and liners, 14.0 cents; labor, repairs and stores, 1.5 cents; a total of 28.0 cents, or 18.2 cents per ton of ore crushed on the total mill tonnage.

The Tavener Process.—In *Bulletin* No. 29 of the Institution of Mining and Metallurgy, London, Feb. 14, Mr. L. Swinney summarizes the advantages of the Tavener process over the old process of pot smelting in the recovery of gold from the by-products of the extractor house as follows: (1) In the Tavener process about twenty-one pots of slag, more or less, are obtained from the by-products smelt per month, running about 8 dwt. per ton and weighing about 1.5 tons. This material is taken to the waste dump and its value, about 12 dwt. of gold, or $12.00, is lost per month beyond recovery. On the other hand, in the pot smelting process about 1 ton of slag is obtained which is crushed up and panned for the metallics which it contains, but the value of which even after panning is about 20 ounces per ton. By the addition of 5 ounces of gold contained in the pots and liners and 5 ounces for sundries the total value is brought up to 30 ounces per ton in the rejected products. This slag is stored up and cannot be treated further under the present methods of working. If this 1 ton of slag of the value of 30 ounces were capable of being sold, the buyer would only pay 50s. an ounce, thus entailing a dead loss of 15s. per ounce, or a total of £22 10s. per month. (2) The gold slime is merely dried in the drying furnace in the Tavener process, and is slightly moist when mixed up with the fluxes, whereas in the pot process it is calcined. Therefore, practically no dust can be carried up the flue by the draught, in the former process, and the loss is slight when compared with the amount lost in the pot-smelting process. (3) At any time the whole amount of gold in slags, furnace sweepings, cupels, etc., could be recovered by the smelter at 40 hours notice by means of the by-products smelt. Thus there is no gold locked up in any of the by-products and very little is sent to the dump. In the pot process, on the contrary, a considerable amount of gold is locked up in the slags, liners, etc., of which gold only about half the value can be saved after

many months waiting for a sufficient accumulation of slags to pay the buyer to take it away. (4) During the smelting process the bath of lead contains at the most 10 per cent of gold, this dilution of the charge rendering the working much more safe than that of the pot-smelting process. The loss of gold in case any lead is lost is therefore small, and at any time the lead can be treated again. On the other hand, in pot smelting the smelter works with a rich product and there is danger of some of the pots breaking and scattering their gold contents. (5). In the pot process the manganese used drives the silver into the slag, the resulting bullion being often 900 fine, but containing very little silver. The latter can be obtained by a clean-up smelt, but the resulting bullion is so rich in silver that an addition of gold-bearing bullion has to be made so as to bring it up to the standard of fineness required by the buyers.

The Assay of Silver Bullion.—Mr. J. Clennell, in the *Bulletin* of the Institution of Mining and Metallurgy, London, Feb. 14, gives a description of a modification of Volhard's method used for preliminary bullion assays at the Redjang Lebong mine, Sumatra. The principal standard solution was nitrate of silver made by dissolving 2.5 gr. pure silver foil in dilute nitric acid, helping to expel nitrous fumes and diluting to one liter. A solution of potassium or ammonium thiocyanate was prepared and adjusted to correspond exactly with this silver nitrate solution. This particular strength of silver nitrate and thiocyanate gave a convenient volume, namely, about 30 cc. of thiocyanate used, in titrating the solution from 0.1 gm. of bullion. The latter amount was weighed out, dissolved in about 50 cc. of nitric acid (25 per cent by vol.), the liquid, after boiling well, decanted into a somewhat large flank and the residue boiled again with stronger acid (75 per cent by vol.). The residue was washed, dried, ignited and weighed as gold. The solution was cooled under the tap, mixed with about 5 cc. of a ferric indicator, made by oxidizing a fairly strong ferrous sulphate solution, and a measured excess of the thiocyanate added with thorough agitation. The red color was then removed by the careful addition, drop by drop, of the standard silver nitrate solution. The finishing point was fairly sharp, it being possible to estimate with care to about 0.05 cc., corresponding to 1.25 parts of silver per 1,000. When it was sought to increase the accuracy by using a weaker silver nitrate solution for titrating back, or a weaker thiocyanate solution for restoring the color, it was found that the exact finishing point was too indefinite to be of any practical value. Increasing the amount of bullion was inconvenient, owing to the bulk of the precipitate, but sometimes 0.5 gm. of bullion were treated as described above, slightly increasing the amount of acid. After adding the excess of this cyanate the flask was well agitated and allowed to stand until the precipitate had thoroughly settled. It was then decanted and washed once or twice by agitation and settling, no filter being used. The liquid poured off was then titrated back with silver nitrate and the accuracy could thus be increased to 0.25 parts silver per 1,000. The method was never relied on as final, but as a useful indication as a preliminary to the fire assay, the results being generally somewhat lower than the latter; copper, lead, zinc and selenium in ordinary amounts did not interfere.

Roasting Argentiferous Cobalt-Nickel Arsenides.—The results of an investigation of the behavior of the argentiferous cobalt-nickel arsenides of the Temiskaming (Ont.) district during washing, made in the laboratory of Columbia University by Prof. H. M. Howe, Dr. W. Campbell and Mr. C. Knight, are given in a paper published in the *Bi-Monthly Bulletin* of the Am. Inst. of Mining Engineers, January. The ores of the district are native silver, with small amounts of dyscrasite (Ag_3Sb), argentite (Ag_2S), pyrargyrite (Ag_3SbS_3), smaltite ($CoAs_3$), chloanthite ($NiAs_3$) and niccolite (NiAs), while mispickel (FeAsS) and cobaltite (CoAsS) occur in similar quantities. The ore used in the investigation was chiefly smaltite, containing a total amount of 689 ounces silver to the ton and 56 per cent of arsenic. The roasting was done by heating the ore, which was held in shallow pans in a gas furnace. The object of the investigation was to ascertain (1) the temperature at which the arsenic is most rapidly expelled; (2) the thoroughness with which it is expelled by prolonged roasting at this temperature and (3) the effect of adding charcoal near the end or at the beginning of the roast. It was found that 15 per cent of arsenic per 100 of ore, that is, 27 per cent of the total arsenic is expelled below 700°, but that the rest of the arsenic is not expelled until the temperature reaches about 840°, when rapid expulsion again sets in. By revolving at temperatures above 840°, the percentage of arsenic can be further reduced by about 24 per cent, that is, down to 17 per cent in the ore, from the original 56 per cent; in this range of temperature the arsenic is removed much faster than at lower temperatures. On account of this behavior the authors conclude that the behavior of smaltite during washing is probably analogous to that of pyrite, which latter loses its first atom of sulphur much more readily than the second, though unlike the pyrite, which frits when suddenly heated, the smaltite ore may be raised suddenly to 800° without harm, as it remains open and porous. The addition of charcoal either at the beginning or towards the end of the roast failed to increase the expulsion of arsenic. Finer grinding of the ore, after it had been roasted once, and reroasting at about 880° C., showed no further expulsion of arsenic, due to fine grinding.

Copper.

Magnesium for Copper Sand Castings.—The difficulty of producing sound copper castings and its remedies are discussed by Erwin S. Sperry in the *Brass World*, February. The well-known reason of the difficulty is that copper oxidizes very rapidly when melted, and the oxide dissolves in the molten copper as soon as formed. When the oxide is present in considerable amount, the copper runs sluggish and thick, and the castings are exceedingly porous. Charcoal, when used as covering for the copper, reduces some of the oxide, but not all. The most satisfactory remedy is the addition of a small quantity of a very strong reducing agent, which not only reduces the oxide but absorbs the gases. For sand casting of steel aluminium is most suitable, while for copper castings silicon (in the form of the alloy copper-silicon) has proven very satisfactory for many years. Sperry discusses the special advantages of magnesium instead of silicon for copper castings. All that is required in practice is to melt the copper and introduce a small piece of magnesium stick (about 2 ounces to 100 pounds of copper) into the metal, stir, allow the magnesium time to act and then pour into sand castings. The difficulty with using pure magnesium is that it is very light and tends to float on the surface of the copper and burn off without having any beneficial effect. It is, therefore, necessary to push it down under the surface with a pair of tongs. For this reason it is preferable not to use the very light pure magnesium, but a heavier magnesium—copper alloy, containing 90 per cent of copper and 10 per cent of magnesium. This alloy is prepared as follows: Melt 45 pounds of Lake copper under a good layer of charcoal, so that it will not oxidize any more than is necessary, and then introduce, one stick at a time, 5 pounds of stick-magnesium. The sticks occur in commerce in pieces about 6 inches long, and they are held with tongs and pushed down under the surface of the molten copper. When all the sticks have thus been introduced, the whole is stirred with a plumbago stirrer and then poured out into small strip ingots, so that small pieces may be easily obtained by cutting up. If 2 ounces of pure magnesium is the proper amount to be added to 100 pounds copper, then 20 ounces of this 10 per cent alloy should be used instead of the 2 ounces of pure magnesium. A special advantage of the magnesium is its high electrical conductivity; its addition to copper, therefore, does not impair the conductivity of the latter. But to get good copper castings for electrical purposes the best purest copper must be used; the magnesium will not remove arsenic, antimony, bismuth, tel-

lurium, iron and other impurities. Besides reducing the oxide in the copper the magnesium acts as an absorber of gases, especially carbon monoxide gas. The reaction yields carbon and magnesium oxide, that is, two solids from the gas, so that the possibility of the formation of blow-holes is removed.

The Constitution of Ferro-Cuprous Sulphides.—An extended laboratory investigation, undertaken for the purpose of ascertaining whether, as maintained by Gibb and Philp, ferrous and cuprous sulphides form the chemical compound $5Cu_2S.FeS$, was carried out by H. O. Hofman, W. Caypless and E. Harrington at the Massachusetts Institute of Technology. The author constructed the freezing point curve of the series ferrous sulphide cuprous sulphide, and subjected the various alloys to microscopical examination. The two sulphides were prepared by heating metallic iron and copper with stick sulphur. The results of the investigation, together with several microphotographs are given by the authors in the *Bi-Monthly Bulletin* of the Am. Inst. of Mining Engineers, January. They arrive at the following conclusions: 1. Ferrous and cuprous sulphides form no chemical but a eutectiferrous compound. 2. The structure of the eutectic of ferrous and cuprous sulphides becomes merged in that of the pure ferrous sulphide and cannot be distinguished from it. 3. The limited reciprocal solubility of the two sulphides diminishes along the cuprous sulphide branch of the curve, slowly at first, then more quickly; solubility is complete beyond the alloy FeS, 20 per cent, and Cu_2S, 80 per cent.

Zinc.

Decomposition of Blende.—The pyrite deposits of Meggen in Westphalia are of great importance to Germany for the manufacture of sulphuric acid. The residues, however, contain several per cent of zinc, as sulphide, and for that reason are not salable to the blast furnaces. It would be of considerable value if a process were found whereby the zinc and sulphur could be practically removed. C. A. Graumann undertook the study of this question in the Institute for Metallurgy and Electrometallurgy at Aachen, and reports his results in *Metallurgie* for Feb. 8. If this residue is heated to melting, it gives off some sulphur and some zinc vapors, but the amount thus expelled is insufficient. Mixtures of Fe_2O_3 and ZnS were heated in a magnesia-lined porcelain crucible in an electric resistance furnace, arranged for the passing of gases through the furnace. A mixture in the proportions $2Fe_2O_3$ to ZnS (16 and 4.88 grams, respectively), heated 1 hour to 1,280° in a current of nitrogen, acting as an indifferent gas. Only 10 per cent of the zinc and 20 to 30 per cent of the sulphur was removed in this way. The experiment was repeated in an atmosphere of air, which partly formed CO_2 with the carbon terminals used in the furnace. Held at 1,280° to 1,300° for an hour, 70 per cent of the zinc and 75 per cent of the sulphur were removed. Further experiments showed that ZnS heated with FeO gives off neither zinc nor sulphur. Mixtures of $ZnS + 3Fe_2O_3 \times 9C$ were then heated, the product at 1,200° was not melted, but sintered. Two experiments showed 87 and 93 per cent of the zinc and 42 and 60 per cent of the sulphur, respectively, eliminated. This result leads to the proposal of the following commercial process of treating blende itself. The blende is intimately mixed with finely divided iron, produced as sponge by the reduction of iron ore. The mixture is to be heated to 1,300°, when zinc distils off quantitatively

RECENT METALLURGICAL PATENTS

Iron and Steel.

Roasting and Agglomerating Pyrite-Cinder.—Pyrite cinder and other pulverulent materials, on account of their dust-like nature, cannot be treated in the same manner as lumpy ore. It has been proposed (see, for instance, our Vol. IV., p. 351) to subject the pyrites cinder to a desulphurizing and agglomerating treatment in an inclined rotary kiln, whereby they are formed into coherent lumps or nodules. Serious difficulties have been encountered in this treatment on

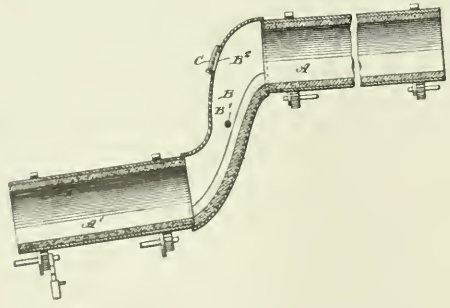


FIG. 1.—ROASTING AND AGGLOMERATING PYRITE CINDER.

account of the tendency of the pasty or semi-fused mass to adhere mechanically to the lining of the kiln or to enter into chemical combination with the kiln lining. R. F. Hill (847,664, March 19, 1907, assigned to General Chemical Co.) tries to overcome this difficulty by dividing the process into two steps. There are two rotary kilns A and A', both inclined and one arranged at a higher level than the other. The upper kiln is considerably longer than the lower kiln, both are connected by any suitable pipe B, which is pivoted at B', and is provided with a valve C, controlling an air inlet B^2. The upper kiln has an ordinary firebrick lining, while the lining of the lower kiln is basic, or at least neutral, being made of chrome, magnesite, bauxite, carborundum or steel brick. The connecting pipe B, or at least the lower portion of it, has also a basic or neutral lining. The pyrite cinder is fed at the upper end of the upper kiln A, while the fuel (as a coal-dust flame) enters at the lower end of the lower kiln A'. The roasting is performed in the upper kiln, and the temperature should be sufficient for this purpose but not high enough to melt the sulphide or cause the ore to sinter into lumps. In the lower kiln the material is formed into coherent lumps or nodules, the size of which depends upon the inclination of the lower kiln and also on the speed with which it is rotated. In the upper kiln no accretions will be formed to the linings, because the temperature is not high enough. In the lower kiln chemical combination between the ore and the lining is prevented by using a basic or neutral lining. If some of the fused material might adhere mechanically to the lining of the lower kiln, the remedy is to increase the temperature in the same, so as to melt the adhering mass away. Of course, this must not result in any undue rise of the temperature in the upper kiln, and this is prevented by admitting a greater amount of air through C to the connecting pipe. The mechanisms for rotating the two kilns are independent of each other. If the method is a commercial success, it is a new example of the old metallurgical rule that it is wrong policy to try to perform two different operations in one and the same apparatus.

Special Steel for Gun Forgings.—A patent of J. Churchward (846,979, March 12, 1907) refers to the production of a nickel-titanium steel stated to be specially valuable for constructing gun forgings and other steel parts which have to resist high temperatures and great strains. A good working

proportion is stated to be 95 per cent of steel (containing from 0.1 to 0.6 per cent of carbon), 3 per cent of nickel, 0.5 per cent of manganese and 1.5 per cent of titanium. The addition of manganese is necessary, since without the same the titanium, coming in contact with the steel, would get chilled (on account of the high melting point of the titanium), and would not properly assimilate with the steel. The procedure for making the alloy is as follows: "The titanium is melted in a crucible at a temperature, say, of about 3,000° C., and the steel and nickel are melted in another crucible and heated up to a point just below the point of volatilization of that metal having the lowest volatilizing point. The manganese is now added to the molten titanium, and while it is being melted and incorporated with the latter the molten nickel steel alloy from the other crucible is gradually added by pouring it in, and the alloy formed may be poured or cast directly into the mold."

Special Steel for Electrical Purposes.—The indefatigable work of R. A. Hadfield, of Sheffield, England, in connection with special steels and kindred subjects is so well known that nothing more need be said. His latest American patent (842,403, Jan. 29, 1907) refers to an alloy having magnetic and electric properties especially adapting it for use in ballast coils, transformer plates and like electrical apparatus, for which it is of great importance to reduce the total magnetic and electric losses to the lowest possible degree. Besides pure iron (containing less than 0.12 per cent of carbon) the steel contains from 2 to 4.5 silicon, less than 0.7 manganese and less than 1.3 per cent aluminium. Two special prescriptions are as follows: The first is 0.08 C, 3.98 Si, 0.08 Mn, 0.95 Al.; the other is 0.09 C, 3.57 Si, 0.67 Mn and 0.1 Al.

Precious Metals.

Extraction of Gold from Refractory Ores.—A patent of J. W. Worsey and E. Hoal (846,768, March 12, 1907) describes a process primarily intended for extraction of gold from refractory ores, but stated to have a wider application. The ore is first crushed and screened and freed from aluminium silicates in any known manner. It is then "subjected to the action of nascent bromide of chlorine produced in the body and presence of the ore by mixing with the powdered or crushed ore or salt of chlorate of soda and bromide of soda, or a chlorate and bromide of other equivalent alkali or a chloride and bromide of an alkaline earth." The mixture is quietly stirred and some acid is added, and the temperature is raised from time to time until it rises to about 150° F. After this treatment has been carried out for about 4 hours, the temperature is raised to near boiling point for the purpose of completing the dissolving of the gold and finally to free it from excess of gaseous products. The whole is then allowed to settle; the clear solution is decanted away and the residue is washed with hot water. The solution and the wash water are mixed together, and any acid present is neutralized by means of a quantity of a solution of an alkali. A weak solution of a lead salt is then added and the whole vigorously stirred, and H_2S is added to the solution under proper stirring (by blowing air through) for 10 to 20 minutes. The whole then turns quite black, and in this condition the precipitated gold and lead sulphide settle out, and are collected, dried and the gold recovered by a smelting operation." To recover any residual gold contained in the ore previously separated from the gold solution, it is treated and washed in a vat with a weak solution of double or single ferroprussiate of ammonium and commercial soda carbonate after the manner of ordinary leaching. The effect of this is that all the residuary gold in the ore is dissolved out of it, and this is effected quickly—namely, within 24 hours. The gold is dissolved out in the first stage as bromo-chloride, and afterward when heated it resolves itself into auric chloride, $AuCl_3$. In this treatment the ferro-prussiate of ammonium acts as an expeditor or saver of time, and by it the residual ores of this and other gold-extraction processes can be economically treated and gold extracted and within a greatly reduced time. The solution resulting from this leaching operation can be treated like the previous solution and sulphide of hydrogen (H_2S) for the separation of the auriferous lead sulphide."

Copper.

Chlorination Process.—O. Froelich (846,657, March 12, 1907) suggests the following wet process of treating copper ores and smelting products, for which comparatively high rapidity of operation, the absence of roasting and smelting and the possibility of treating the poorest ores and smelting products are claimed. The ore is first subjected in the absence of air to "a temperature between 150° and 800° C.," whereby the loose sulphur is driven off. The pyrite is changed by this operation in its chemical composition and can then be chlorinated much quicker and better. As chlorinating gases, chlorine, vapor of hydrochloric acid and of ferric chloride are used. The chlorine and the ferric chloride attack the sulphur compounds of copper, the hydrochloric acid and the ferric chloride attack the oxides of the copper. The proportion of the gases and vapors in the mixture are adjusted to the composition of the copper ore. Steam may also be added to the chlorinating mixture. It is preferable to make the temperature of the chlorination somewhat higher than the boiling point of the ferric chloride, about 300° C.; but it can be lower if the copper in the ore only occurs in combination with sulphur. In this case only chlorine gas is used. If iron is present in the ore it is chlorinated together with the copper, but more slowly, and the process is facilitated by a higher temperature. In order to regain the chlorine combined with the iron, the ore or smelting product is heated to about 300° or more after chlorination, and a certain quantity of air is introduced during this operation.

The ferric chloride is then evaporated, and by the air separated into oxide of iron and chlorine gas, both of which are collected. The chloride of copper is not changed by this operation. Then the ore is treated with hot water and the chloride of copper and, perhaps, a residue of the ferric chloride are extracted. The solution is then introduced into a rotating apparatus containing pieces of iron, and the metallic copper is deposited in form of cement copper. The solution now contains mainly ferrous chloride, and in order to regain the chlorine from it the solution is oxidized in a rotating drum to ferric chloride by means of an air blast. Then the water and the water of crystallization are driven off by heating, and by increasing the temperature over the boiling point of ferric chloride and introducing a certain quantity of air, chlorine gas and ferrous chloride are obtained. If, in this operation, hydrochloric acid is formed, it can be transformed into chlorine by treating with calcium hypochlorite.

Treatment of Copper Silicates.—To treat silicates of copper of vitreous and anhydrous formation by a leaching process, G. H. Waterbury (847,448, March 19, 1907) subjects them first to a light or red roast, by means of which the formation is quickly changed to a black oxide and the vitreous form of the silica is disintegrated. The ore thereby becomes amenable to the ordinary leaching process.

Roasting Process.—At another place of this department the description of a roasting process of A. Lotti for lead sulphide ore will be found, which is also suitable for the treatment of low-grade copper matte and of sulphide ores of copper, arsenical or antimonial. According to the inventor, a special advantage of his process is that there is no necessity of briquetting and that such ores are desulphurized and brought at the same time into excellent form for smelting. As in the case of lead, the ore is mixed with a proper proportion of molten slag, and in some cases a silicious sand or finely crushed fluorspar, rich in silica, is added prior to the application of the air blast. The air blast is, of course, applied while the sulphides are still at the temperature of combustion.

Flux for Welding.—T. W. Wilson (847,629, March 19, 1907), patents a flux consisting of approximately equal parts

of a borate, specifically borax, and a nitrate, specifically saltpetre. The components are finely divided and intimately mixed. The ends of the copper pieces to be welded are bevelled, cleaned and heated and then the mixture of borax and saltpetre is applied and melted on the surface. The two copper ends are heated to whiteness and are then welded together by hammering or compression.

Lead.

Roasting Process.—The object of a patent of A. Lotti (847,017, March 12, 1907), is to use the waste heat of the smelting process (in form of hot slag) for the roasting of lead or copper sulphide ores and for agglomerating them at the same time into a form well adapted for treatment in the blast furnace. For this purpose lead sulphide ore is thrown into a predetermined quantity of molten slag and stirred rapidly, whereby a spongy incandescent material is produced, dense fumes of sulphur, sulphur dioxide and sulphur trioxide being evolved at the same time. The material thus produced consists of the sulphide and oxide of lead mixed with slag. This spongy and friable material, while being still at the temperature of combustion, is subjected to a compressed-air current and the remaining sulphur is thereby, to a large extent, burned off, the temperature of the charge rising considerably, even to bright red heat. After 1 or 3 hours the desulphurization is complete and the mass forms a single block of spongy character. It may be broken up to suitable size as preliminary to smelting in the blast furnace, or the block, while still red hot in its interior, may be passed on directly to the blast furnace. It sometimes happens in this process that ores, rich in sulphur, produce in the smelting a little more matte than if they were treated by the ordinary roasting process, but in such a case the difficulty may be overcome by retreating a certain proportion of the matte, crude or roasted, along with the ore. This has the advantage of oxidizing, to a large extent, the matte, which then acts as a flux in the subsequent smelting.

Nickel.

Treatment with Chlorine.—C. A. Diehl and W. Koehler (842,139, Jan. 22, 1907) have designed the following method for treating nickel ore, matte, etc., as a preliminary to leaching, for the purpose of getting a pure nickel chloride solution. The ore which may contain nickel, magnesium, aluminium, and iron, with or without gangue, is first chloridized by known methods in order to effect the more or less complete conversion of the several metals into chlorides. The chloridized ore is then heated in a drum in an atmosphere containing oxygen, either in form of free oxygen or air or steam. The temperature should be below the point of decomposition of nickel chloride, but above the point of decomposition of the remaining "base" metals. The reaction

$$M''Cl_2 + M_2'''Cl_6 + 2O_2 = M''O + M_2'''O_3 + 4Cl_2$$

takes place if the temperature is sufficiently high and air is used as oxidizing agent. On the other hand, if steam is used, the reaction is

$$M''Cl_2 + M_2'''Cl_6 + 4H_2O = M''O + M_2'''O_3 + 8HCl$$

If a mixture of air and steam is employed, the two reactions occur simultaneously, with the result that a mixture of chlorine and hydrochloric acid is obtained. These may be utilized for chloridizing further quantities of ore. In the above equations M'' represents, of course, a bivalent metal—magnesium, zinc, barium, etc.—and M''' a trivalent metal—iron, aluminium, etc. The chlorides of the trivalent metals are not easily completely decomposed by oxygen, but such decomposition occurs readily and with substantial completeness in presence of the chlorides or oxides of the divalent metals. For this reason if one or more divalent metals are not already present in the ore, they are preferably added. Under such conditions and at a suitable temperature, which, in the specific instance described, is below red heat, there occurs a combination between the oxides of the divalent and trivalent groups, forming double oxides of the general type $M''O,M'''_2O_3$, which are relatively stable compounds and are only very slowly soluble in the water or dilute acid employed in the subsequent leaching. Their solubility is further decreased by heating in presence of hydrochloric acid or chlorine, as is the case in the practice of the method above described. Furthermore, the physical state of the resulting material is such as to permit the rapid and substantially complete extraction of the nickel by leaching with dilute acid. No injurious effect follows from the presence of an excess of divalent oxide, since any oxide or hydroxide of nickel which might be precipitated thereby is readily soluble in the dilute leaching acid.

Production of Nickel Chloride Solution.—R. W. E. MacIvor (846,492, March 12) patents the following process for treating nickel ores or oxidized nickel matte for the production of a solution of nickel chloride, from which the nickel may be recovered by known methods. The ground ore or oxide is "digested under pressure in a solution of chloride of magnesium, which gives a solution containing chloride of nickel."

Zinc.

Zinc from Iron and Zinc Sulphide Ores.—Elsewhere in this department, under the heading Nickel, a process of Diehl and Koehler is described, which may also be applied to winning zinc from sulphide ores, containing iron and zinc, the iron existing in the ore in the ferrous condition. Such an ore is first chloridized, to convert both iron and zinc into chlorides, and is then roasted in an oxidizing atmosphere at such a temperature that the chloride of iron is decomposed, but not the zinc chloride. The roasted ore contains ferric oxide and zinc chloride, of which the latter is extracted by leaching.

Alloys.

German Silver.—A. E. Hobson (846,851, March 12, 1907; assigned to International Silver Co.) patents the composition of a German silver alloy of fine appearance and very durable, and which may be freely worked and spun without liability of fire cracking. The alloy consists of copper, zinc, nickel and manganese, but the manganese should not be in excess of 4 per cent of the entire amount nor the zinc in excess of 20 per cent of the entire amount. The nickel and copper may vary, but a relatively high proportion of copper is generally used. Two suitable prescriptions are as follows: 67 per cent Cu, 20 Zn, 10 Ni and 3 Mn, or 59 per cent Cu, 20 Zn, 18 Ni and 3 Mn.

Mercury.

Mercury Retort and Furnace.—C. F. Brown (847,399, March 19, 1907) patents a mercury furnace consisting of a long inclined chute, through which the mercury ore, supplied at the top, slides down. Below this ore chute is provided a flue for the ascending heating gases, so that the bottom of the ore chute is at the same time the top of the gas flue. The ore passing down in the chute is heated by the gases passing upwards in the flue. The mercury vapor is carried off through a passage at the top of the ore chute. In order to assist the carrying off of the mercury vapor the following arrangement is made: The heating gases in their upward passage through the flue meet at intervals certain abutments, and at these places passage is provided for part of the heating gases to enter into the ore chute, where they mingle with the descending ore and help carrying off the mercury vapor to the exit at the top, while at the same time the ore is dried.

Mercury Condenser.—The same inventor (847,547, March 19, 1907) has devised condensing apparatus for the mercury vapor, consisting of a series of chambers. Partitions are provided in each chamber so as to fill partly the cross-section in such a way that the mercury vapor in passing from one end of the chamber to the other end is forced to pass along a zig-zag path. Near the top of each chamber water pipes are provided so that the hot vapors which ascend to the top are cooled and the mercury is condensed and drops down to the

bottom of the compartments, and from there into troughs sloping down from one side of the chamber to the other, from which the mercury can be drawn off at intervals. The inner brick walls of the condensing chambers are formed with a glazed surface, preventing the penetration of the mercury vapor into the brick. Since in the condensation of the mercury minute particles adhere to all the interior surfaces, the interior is thoroughly washed at intervals, so as to remove these particles. For this purpose apertures are provided near the top through which a hose may be introduced.

Laboratory Induction Furnace.

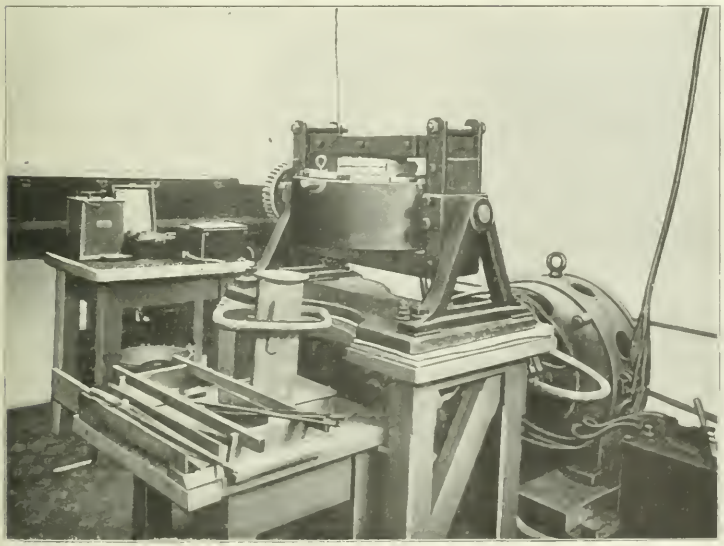
The following details refer to a Kjellin induction furnace for laboratory purposes, which was exhibited at Sheffield during October last, and which presents some interesting features. The adjoining illustration gives a view of the furnace.

The furnace has a maximum capacity of 15 kw., and is designed for a frequency of 150 to 200 cycles per second. The furnace has been specially built for this high frequency to suit the conditions at the laboratory in which it was to be installed after the exhibition. It is, of course, well understood that the design of an electric induction furnace is rendered very much more difficult by use of a high frequency, and for this reason the behavior of the furnace, as given in the record of tests below, is remarkably good and the power factor very satisfactory, in view of the high frequency and the comparatively small size of furnace.

The furnace was originally intended for melting platinum, but at the exhibition was used for melting steel, and for this purpose it proved a thorough success, several castings being made on several days of the exhibition. A furnace of the size exhibited will pour an ingot of about 30 pounds.

The furnace is built as a tilting furnace, just like the Kjellin furnace now in industrial operation for steel refining in the steel works at Voelklingen, as described and illustrated in our last issue, page 92. It is, of course, easy to so change the design as to use currents of a lower frequency than 150 to 200 cycles.

The lining is made of magnesite and gave no trouble.



KJELLIN TILTING INDUCTION FURNACE.

The tests, of which a record is given below, were made on the afternoon of Saturday, Oct. 20, 1906:

Second Run, 200 Cycles.

Time	*Volts.*	*Amps.*	*Watts.*	*Power Factor*
6.00	195	39	4,320	....
6.03	205	40	4,700	0.57
6.08	220	35	4,080	....
6.14	225	36	4,600	....
6.16	215	40	5,200	0.605
6.18	215	40	5,040	....
6.20	210	41	5,310	0.62
6.22	teemed			

Third Run, 200 Cycles.

Time.	*Volts.*	*Amps.*	*Watts.*	*Power Factor.*
8.00	205	40	....	....
8.15	207	40	....	....
8.17	212	38	4,200	....
8.20	207	40	5,030	0.61
8.25	213	38.5	4,800	0.60
8.27	...	43	....	....

The Kjellin induction furnace is built in this country by the American Grondal-Kjellin Co., of 45 Wall Street, New York City, and we hope to report on some interesting developments on a commercial scale in one of our next issues.

Ball Filling Material for Sulphuric Acid Towers.

In our Vol. IV., p. 466, we described the machine-made, perforated, Guttmann hollow earthenware balls of the Deutsche Steinzeugwaarenfabrik, of Friedrichsfeld, which are extremely suitable as a filling material for sulphuric-acid towers.

In a recent issue of the *Chemical Trade Journal*, Mr. Rudolf Heinz gives the results of an English installation of these balls.

A set of chambers of a capacity of 96,000 cubic feet, working on spent oxide, was provided with a Gay-Lussac tower, 8 feet square and 40 feet high, and 4,560 pounds of sulphur were burnt daily. It was only with great difficulty that the charges could be maintained at this quantity, and the Gay-Lussac tower was insufficient for the work. Two towers were then inserted into the set, firstly, a round intermediate tower between the second and third chambers, 6 feet in diameter and 13 feet 9 inches high, filled with about 10,500 Guttmann's patent 4-inch balls, and, secondly, a round preliminary Gay-Lussac, 5 feet 6 inches in diameter, and 11 feet high, filled with about 6,500 of these balls. The result of this change was very remarkable indeed. The charges could be increased by 23.16 per cent, so that now 5,616 pounds of sulphur are burnt daily. The small preliminary Gay-Lussac tower, of which only 160 cubic feet were filled with balls, does almost the whole of the work, the gases issuing therefrom being nearly colorless.

The analysis of these gases showed a total acidity of 3.52 grains per cubic foot at the inlet, and 2.30 grains at the outlet of the preliminary Gay-Lussac tower. Crowder, in the *Jour-*

...of the Society of Chemical Industry, 1891, p. 303, gives the following data:

	Total Acidity.	
	At the Inlet of the Gay-Lussac.	*At the Outlet of the Gay-Lussac.*
New Mest kilns	3.54	2.03
Lump ore kilns	3.55	1.80

It is thus seen that the little ball Gay-Lussac has really been doing almost the whole of the work that is generally demanded from the usual large Gay-Lussac tower, and the effect in future will be that sulphuric acid works will be able to dispense with these costly and cumbersome pieces of apparatus.

The Deutsche Steinzeugwarenfabrik as manufacturer of the Guttmann hollow balls, is represented in this country by Messrs. Fred. Bertuch & Co., of New York City.

Zinc and Lead in Upper Mississippi Valley.

An old and famous mining region in which certain fundamental notions of ore deposit were first worked out is that part of the Upper Mississippi Valley celebrated for its zinc and lead mines. The boundaries of the region are in part indefinite, since sporadic occurrences of the minerals are found outside the mining region proper, but it is usual to define the area as including Grant, Lafayette, and Iowa Counties in Wisconsin, Jo Daviess County in Illinois, and an irregular narrow belt of territory in Clayton and Dubuque Counties paralleling the Mississippi River in Iowa. Dubuque, Galena, Platteville, and Mineral Point are the leading cities.

One man can do little toward solving the problems of such an area. It must be the work of many, and perhaps of years. This region has in fact been the scene of labor of some of our keenest students of ore deposits. A recent publication (Bulletin No. 314) of the United States Geological Survey, which is entitled "Zinc and Lead Deposits of the Upper Mississippi Valley," by Mr. H. Foster Bain, now State Geologist of Illinois, will therefore be of interest to many students. It is hoped also that it may prove serviceable in the development of the region.

Mr Bain's paper is primarily an account of the present condition of the district and a statement of ideas relating to the formation of the ores. It includes the results of observations, which began in 1899, when he was a member of the Iowa Geological Survey, and together with Professor Samuel Calvin made a study of the geology and mining industry of Dubuque County.

In 1893 Mr. Bain studied the mines of Jo Daviess County, Ill., for the Federal Survey and in 1904 the work was extended to cover the Wisconsin mines. As mining developments in this district have recently been very rapid, the publication of Mr Bain's paper, which takes account not merely of the scientific problems presented in this area, but of its industrial growth as well, is especially timely.

It is estimated that from 1821 to 1904 the total lead production of the district was 611,975 tons, which sold for approximately $50,000,000. The maximum production was between 1840 and 1845. In 1845 and again in 1847 more than 27,000 tons of lead were shipped.

The total production of zinc up to 1905 is estimated at 450,000 tons, which probably did not bring much over $10,000,000. The early prices paid for the ore were very low—$3 to $8 for the carbonate and $4 to $12 for the blende.

In recent years the product has been entirely blende, which has sold for much better prices. The zinc production of the district is now rapidly increasing, and for the year 1905 approximated 33,000 tons. Many mines have been opened or equipped since the survey, upon which this report is based, was made. Mr Bain not only describes most of the mines of the district individually but explains the methods of prospecting, mining, and milling here in vogue.

The scientific conclusion of Mr. Bain's consideration of this area may be summarized as follows: "The ores of this region are believed to represent concentrations of material originally disseminated through the surrounding rocks, particularly the Galena and upper Platteville beds. It is believed that the zinc and lead originally present in the crystalline rocks of the Lake Superior district were delivered by rivers to an especially favorable portion of the Ordovician coast, where in warm, shallow waters they were partially concentrated by evaporation and were locally precipitated in quantity.

"The agents of precipitation were hydrocarbons or hydrogen sulphide, or both, derived from decaying masses of algae of a peculiar type irregularly accumulated within certain shallow basins on the sea floor. The rising hydrocarbons continued to be effective throughout the period of deposition of the Galena dolomite.

"As the algae matter became compressed the beds above broke and settled, leaving open spaces of peculiar form for the ultimate reception of the ore bodies. The beds were slightly deformed, whereby the basins were accentuated and deep joint cracks were developed. The area was subjected to peneplanation and later to gorge cutting, whereby the overlying shale was cut away and a vigorus underground circulation was brought about. This circulation resulted in a concentration of the disseminated material, and with the fall of ground-water level the ores were successively reconcentrated until the present type was produced."

Brick for Cupola Linings.

The Harbison-Walker Refractories Co., of Pittsburg, has recently issued an exceedingly interesting and useful pamphlet on the best kinds of brick for cupola linings and on rules to be observed in laying the brick. In view of the enormous amount of experience accumulated by the Harbison-Walker Refractories Co, in many years of activity, the pamphlet should find the careful consideration of foundry superintendents. In the following we give in abstract the most important points:

There are three different classes of fire clays, viz.: soft clays, shale clays and flint clays. The soft and shale clays usually run high in silica and flint clays run high in alumina. Aluminous clays are more refractory than silicious clays, and they can be made into tougher and stronger brick, which is more suitable for use in cupola linings.

Blocks for lining around the bottom of the cupola and for a distance of 2 feet or so above the tuyeres are made by the Harbison-Walker Co. of flint clay high in alumina with sufficient bond clay to make the brick strong and tough. From a distance of about 2 feet above the tuyeres to the charging door, the blocks are made to stand abrasion as well as heat, and they are exceedingly dense, hard and strong.

The use of high-grade material means a greater first expense for the brick, but this is many times balanced in operation by the fact that stoppages for repairs and loss of output are reduced to a minimum. The use of more expensive high-grade material is thus easily seen to represent an important source of economy.

Of course, even with high-grade material it is necessary to avoid deterioration of a lining due to careless operation. One of the sources of failure is excessive pressure of blast, causing an impinging or cutting flame—something like that from a blow-pipe—to play on the brick work. Another reason is excessive slag, or slag of a very scouring nature, which cuts out the lining rapidly. Slag should be kept as neutral as possible. Limestone and oyster shells are the slag materials in most common use.

It is quite possible that the use of chrome brick in the lower part of the lining would prove an economy in the case of a cupola where firebrick cuts out very rapidly. "Chrome" brick will resist almost indefinitely the chemical action of scouring slags, and they are used in lining cupolas which burn basic

materials, such as dolomite and limestone, and for the bottom of soaking pit furnaces where the scouring iron slag cuts out the fire-clay brick.

The best material to be used for daubing is a plastic fire clay and silica. When properly mixed the mixture is plastic and adhesive, it does not crack, expand or contract and stands heat. The fire clay should be soaked for 24 hours or longer, as it absorbs water slowly. The use of split brick pressed into the daubing with the flat side against the lining is effective and is recommended. This, of course, decreases the amount of daubing to be used and prevents skin drying of same, also prevents breaking away from wall as soon as steam is generated behind the skin-dried surface. Split brick can be put in nearly as cheaply and quickly as a cupola can be daubed, and are almost equivalent to a new lining.

Some very useful pointers are given on brick-laying in order to get the best results as follows:

Brick should be laid in that portion of the setting for which they are intended to be used, as conditions vary in different parts of setting and brick are varied to meet conditions.

The clay used should always be of same grade as the brick that are laid with it. This is important, as one of the frequent sources of trouble is the use of inferior clay to lay brick.

Clay should be mixed to a thin soup and brick dipped in same, then rubbed to insure a brick-to-brick joint. Not more than 300 to 350 pounds of clay should be used with 1,000 brick.

All brick-laying should be as even as possible, so as to avoid projecting brick, which catch the flame. A perfect arch or circle over the fire will last almost indefinitely.

Heating up and cooling down slowly adds very much to the life of the brick work.

Cutting of brick should be avoided as much as possible, and regular 9-inch shapes, such as skew, arch, wedge, soap, split, key, etc., used instead of cutting 9-inch straights. A cut brick is never as good as a whole brick.

Notes.

American Electrochemical Society.—At the March meeting of the Board of Directors the following gentlemen were elected members of the Society: Messrs. R. D. Thomas, Oakmont, Pa.; C. H. Korr, Niagara Falls, N. Y., and S. O. Dillon, Bloomington, Ind. The names of the following gentlemen will come up for election at the April meeting: Messrs. William McMurtrie, New York City; Tracy D. Waring Perth Amboy, N. J.; R. W. Lohman, Oakland, Cal.; H. B. North, Madison, Wis.; John L. Harper, Niagara Falls, N. Y. The preliminary programme of the Philadelphia meeting will be found on page 116.

Relative Cost of Power.—We intended to publish in this issue an abstract of Prof. Lucke's paper on the relative cost of power from water, oil, steam and gas, presented at the recent meeting of the New York section of the American Electrochemical Society. Since, however, Prof. Lucke will read a paper on the same subject at the general meeting of the Society in Philadelphia we reserve our report for that occasion.

American Foundrymen's Association and American Association of Brass Founders. According to a recent circular letter, sent out by Dr. Richard Moldenke, secretary of the American Foundrymen's Association, the annual convention will be held in Philadelphia from May 21 to 23. A special meeting of the foundry, rolling mill, plating, supply and other interests connected with the brass industry will take place Wednesday, May 22, at 10 A. M., in the Second Regiment Armory, and it is hoped that the much-discussed organization of the brass interests along educational lines similar to the work of the American Foundrymen's Association may take place. Great efforts are being made to make the convention interesting and enjoyable, and it is expected that the attendance will be even greater than at the last convention in Cleveland, where all records were broken with the registration passing the 800 mark.

Sherardizing.—The American Galvanizing Co. has been formed to operate the Cowper-Coles process of "sherardizing" (a dry process for covering articles with zinc) in this country. The capital is all New York and Pittsburg money, and the New York end of the business is being handled by Messrs. H. W. Poor & Co., of 33 Wall Street.

An Electric Steel Plant in Canada.—A company has been formed in Canada, to be located near Niagara Falls, for the purpose of smelting iron ores and to produce steel and steel castings by the Héroult electric-furnace processes. In Europe there are now four steel plants operating under the Héroult patents, and all now running are without exception a commercial success. The Canada plant is expected to be in operation by about August, 1907. It will also be used as a demonstrating plant to show the process to intending licensees. An experimental department will be added to make further experiments on smelting and treating all kinds of ores by the Héroult electric process.

The United States Steel Corporation's annual report, which has just been issued, shows the trust to be in excellent condition. The "net earnings" were nearly $25,000,000 in excess of the best previous year, 1902.

The Tin Products Co. is a New York corporation which has recently been formed to operate processes of detinning and producing various tin products. Mr. George F. Seward is the president. Among the directors are Messrs. C. E. Acker, Geo. O. Seward and J. A. Wilke. Mr. Acker will leave Niagara Falls and reside in future in New York City.

New Journals.—*Copper and Brass* is the title of a new monthly journal published by the Copper and Brass Publishing Co., of Detroit, Mich., Mr. R. Marshall being the editor. The journal is devoted to the interests of the copper, brass, bronze and aluminium industries. Among the reading matter in the first issue (March, 1907) is the first of a series of elementary articles by H. M. Lane, on sources of the non-ferrous metals, an article by Paul Leake, on the copper situation; notes on molding of odd castings, on the deoxidation of brass and bronze alloys, on aluminium in typewriters, etc. With the beginning of this year a new monthly electrochemical and electrometallurgical journal has made its appearance in France. Its title is *Revue de l'Electrochemie et l'Electrometallurgie*. It is published at 1 Boulevard Saint Germain, Paris, but neither the name of the publisher nor of the editor is given. It seems, however, that the journal is published under the auspices of M. Adolphe Minet. Among the articles published in the first two issues is a summary by M. Jouve, of electrochemical processes for the fixation of atmospheric nitrogen; an article by A. Minet on classification of and literature on electric furnaces; an anonymous article on units and constants of physical chemistry; the Academy paper, by H. Moissan and T. Watanabe, on the distillation of metallic alloys, etc. We extend to our new contemporaries our wishes for a useful and prosperous career.

Electroplaters' Voltmeter.—It has long been recognized that the highest efficiency cannot be obtained in an electroplating establishment without carefully regulating the electrical conditions by means of measuring instruments. But platers have hesitated to equip each tank with a voltmeter on account of the high cost. This drawback is completely overcome in an instrument which has just been placed on the market by the Weston Electrical Instrument Co., of Waverly Park, Newark, N. J. It obviates the necessity of having an instrument for each tank and enables the plater to avail himself of an extremely accurate and reliable instrument at a very low cost. The instrument is really a combination, in one case, of a

voltmeter with a switch, by means of which the voltmeter can be connected to any one of a number of plating tanks in an establishment. We intend to give a more detailed description of the instrument in a future issue.

The Kny-Scheerer Co., of New York City, Department of Laboratory Supplies, have sent us their voluminous catalogue on chemical apparatus and laboratory supplies in the field of general chemistry. It is a bound volume of 612 pages, giving descriptions, illustrations and prices of not less than 5,789 different apparatus and appliances carried in stock by this company. For convenience the names of the different apparatus are arranged alphabetically. The catalogue is issued at present in German, but it is the intention of the Kny-Scheerer Co. to issue it in English at a later date. This company is a consolidation of Vereinigte Fabriken fur Laboratoriums-Bedarf, Berlin; Max Kachler & Martini, Berlin, and Dr. Peters & Rost, Berlin; The Kny-Scheerer Co., New York; The Laboratory and School Supply Co., New York.

Transportable Batteries.—We have received from the General Storage Battery Co., of New York City, a copy of the instructions for the installation, treatment and maintenance of transportable batteries made by this company. The instructions are very clear and to the point.

The Buffalo Dental Manufacturing Co., of Buffalo, N. Y., have recently issued their profusely illustrated catalogue B, list No. 34, on laboratory and workshop appliances, and especially laboratory furnaces, burning gas, gasoline and kerosene, blow-pipes, etc., for colleges, schools, chemists, assayers, jewelers, experimental laboratories, workships, etc.

Cement Making Machinery.—Catalogue 7 of the Power & Mining Machinery Co., of Milwaukee, gives a well-written outline of the methods of manufacturing Portland cement, with very neatly illustrated descriptions of all kinds of machinery used in this industry.

Fire-Proof Materials.—We have received from Messrs. Wendell & MacDuffe, New York City, a pamphlet on their asbestos and cement fire-proof materials. The line includes reinforced asbestos corrugated sheathing, a strong and durable composition of asbestos and cement compressed under strong pressure and reinforced with ¾ inch of woven wire mesh. This material is used as a substitute for corrugated iron, the particular advantages being its lightness, its lasting quality and the fact that it requires no painting whatever. The pamphlet also describes the asbestos building lumber, which is used to a great extent for construction work in electrical plants of all kinds for insulations, door panels, etc.

Modern Plate Glass Plant.—The Crystal City plant of the Pittsburg Plate Glass Co. is now about completed at Crystal City, Mo., 28 miles below St. Louis. There are fifteen buildings of reinforced concrete. It is estimated that 50,000 barrels of cement will be used in the building process, the brand being the "Universal Portland," made in the cement division of the United States Steel Corporation. Even the roofs are to be reinforced concrete tile, 4 feet x 8 feet. The machinery will be driven by electric motors of exceptional size. The power equipment already contracted for includes an 1,800 Allis-Chalmers gas engine, direct connected to a 1,000-kw. Allis-Chalmers generator. This unit will be installed in the same power house with a 5,000-hp. Allis-Chalmers "Big Reliable" engine, which carried the entire lighting load for the illuminating of buildings and grounds of the Louisiana Purchase Exposition at St. Louis; 1,600 hp. in Allis-Chalmers induction motors will be used to drive grinders and polishers.

Austrian Magnesite.—A consular report from Vienna states that the very considerable export of calcined magnesite from Austria to the United States, amounting during 1906 to nearly 53,000 tons net weight from the Vienna consular district alone has attracted general attention and that new magnesite mines are being located in several parts of Austria.

Digest of U. S. Patents.

Compiled by Barnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

Calcium Carbid.

No. 492,377, Feb. 21, 1893, Thomas L. Willson, of Leaksville, N. C.

Refractory ores or compounds, such as those of barium, calcium, magnesium, titanium, tungsten, zirconium, silicon and boron are smelted in an electric arc furnace. The process, which is specifically described for the production of aluminum, aluminum carbid or aluminum bronze is said to have been used for the reduction of calcium oxid and production of calcium carbid. The furnace shown is a carbon or graphite crucible set in a fire-brick shell and serving as one electrode, preferably the positive one. It rests on a terminal iron plate which is bolted to the dynamo main. An adjustable carbon rod electrode depends into the crucible, which is covered by a plate, or two plates of carbon. An arc is sprung between the crucible and carbon rod and a mixture of the alumina or other compound, mixed with finely divided carbon, is introduced through a notch in the top edge of the brick-work, falling around the lower end of the rod, whereupon reduction proceeds. The rod is raised and kept at such height as to maintain the arc. Enough carbon is used in the charge mixture to prevent the formation of a fused bath, consequently there is no ebullition in the crucible. The alumina may be first introduced and fused and as it reaches ebullition the requisite amount of comminuted carbon be introduced, which then becomes commingled with the alumina by the violent circulation suppressing the ebullition. Fifteen per cent by weight of carbon is sufficient to prevent the formation of a fused bath, but if the material is coarse or not intimately commingled, a larger proportion may be necessary. The charge mixture may be made by drying, coking and powdering alumina impregnated with tar. Two modes of recovering aluminum are described: First, by maintaining a pool of molten copper or other alloying metal in the bottom of the crucible. Portions of the copat frequent intervals in small quantities. The mixture of alumina and carbon floats upon the bath of aluminum bronze per, alumina and carbon are preferably introduced alternately as a quiescent mass. Second, by employing such excess of carbon in the charge as to produce aluminum carbid, from which the metal may be subsequently abstracted. The product may be tapped out of the furnace through a hole closed by a plug of aluminum or clay. The arc is maintained close over that portion of the charge which is undergoing reduction. Two carbon-rod electrodes may be employed, with an arc sprung between their lower ends, or with two arcs in series between their lower ends and the charge.

No. 541,137, June 18, 1895, Thomas L. Willson, of New York, N. Y.

Produces crystalline calcium carbid by electrically smelting a mixture of finely divided coke 35 per cent, and lime 65 per cent. The furnace comprises a wall of brickwork inclosing a carbon crucible, seated on a metal plate which is connected to one pole of an alternating-current dynamo. A layer of broken carbon is placed in the bottom of the crucible. A tap-hole extends through the lower end of the crucible and the brickwork. The other electrode is a depending carbon rod, adjustably supported. The dynamo supplies alternating current at a potential of 55 volts. The amperage for an electrode measuring 8 inches on the side may be 1,500. The molten carbid may be tapped out or may be allowed to accumulate in the crucible to a height of 2 feet or more, itself constituting the lower electrode. The alternating current at fifty reversals a minute assists the feeding of the pulverized charge into the arc by producing a series of explosions, and the yield per electric horse-power is almost double that of a process using direct current.

NEW BOOKS.

Electrochemistry.—First Part: Theoretical electrochemistry and its physico-chemical foundations. By Dr. Heinrich Danneel. Translated from the German by Edmund S. Merriam, Ph. D. 181 pages, 18 illustrations. Bound in cloth. Price, $1.25 net. New York: John Wiley & Sons.

Introduction to Physical Chemistry.—By James Walker. Fourth edition. 387 pages, illustrated. Price, $3.25 net. New York: The Macmillan Co.

Chemical Experiments.—Prepared to accompany Remsen's "Introduction to the Study of Chemistry." By Ira Remsen. Third edition revised by John Elliott Gilpin. 160 pages, illustrated. Price, 50 cents. New York: Henry Holt & Co.

Introduction to Metallurgical Chemistry.—For technical students. By J. H. Stansbie. Second edition. 252 pages, 45 illustrations. Bound in cloth. Price, $1.25 net. New York: Longmans, Green & Co.

The Manufacture and Properties of Iron and Steel.—By Harry Huse Campbell. 659 pages. Price, $5. New York: Hill Publishing Co.

Gold Mining Machinery.—Its selection, arrangement and installation. By W. H. Tinney. 308 pages, illustrated. Price, $5 net. New York: D. Van Nostrand Co.

Elements of Mining, Geology and Metallurgy.—A practical field and office manual, reference compendium, treating on the geology of mining and metallurgical methods of Western America. By G. Washington Miller. 489 pages, illustrated, folded plate diagrams. Price, $5.50. Denver, Col.: *Daily Mining Record.*

Principles and Practice of Coal Mining.—By James Tonge. 364 pages, illustrated. Price, $1.60 net. New York: The Macmillan Co.

Mining Law in Practice.—A brief and comprehensive treatise with geometrical illustrations of mining rights and correct methods of locating, holding and acquiring patents to United States mineral lands, according to Federal statutes and common practice. By G. Washington Miller. 292 pages, illustrated. Price, $2. Denver, Col.; Ores & Metals Publishing Co.

Steam Turbines.—Theory and Practice. By Lestre G. French. 418 pages, many illustrations. Battleboro, Vt.: *The Technical Press.*

Henley's Twentieth Century Book of Recipes, Formulas and Processes.—Containing nearly ten thousand selected scientific, chemical, technical and household recipes, formulas and processes for use in the laboratory, the office, the workshop and in the home. Edited by Gardner D. Hiscox, M. E. 787 pages, illustrated. Bound in cloth. Price, $3. New York: The Norman W. Henly Publishing Co.

German Monographs on Applied Electrochemistry.—Vol XXVI. Elektrometallurgie des Eisens. By Prof. Dr. Bernhard Neumann. With 89 illustrations; paper cover. Price marks 7 (in New York, $2.35.) Halle a. S.: W. Knapp.

German Monographs on Applied Electrochemistry.—Vol XXVII. Die Elektrolytische Gewinnung von Brom und Jod. By Dr. Max Schlötter. 50 pages; 18 illustrations; paper cover. Price, marks 2.40 (retail price in New York, 80 cents.) Halle a. S.: Wilhelm Knapp.

A Text Book of Electrochemistry.—By Max LeBlanc. Translated from the fourth enlarged German edition by Willis R. Whitney, Ph. D., and John W. Brown, Ph. D. 338 pages, 47 illustrations; bound in cloth. Price, $3.60 net. New York: MacMillan Co.

Census of Manufactures: 1905—Petroleum Refining.—Department of Commerce and Labor, Bureau of the Census Bulletin 70. 57 pages, illustrated. (A review, by Dr. Chas. E. Munroe, of the industry, with full statistical data. As appendix a bibliography is given with an exceedingly useful Digest of United States patents relating to petroleum refining.)

BOOK REVIEWS.

Handbook of Metallurgy. Vol. II.; Zinc, Cadmium, Mercury, Bismuth, Tin, Antimony, Arsenic, Nickel, Cobalt, Platinum, Aluminium. By Dr. Carl Schnabel. Second English edition. Translated by Henry Louis, M. A. 867 pages, 532 illustrations. Price, $6.50 net. London and New York: The Macmillan Co.

This book completes the second English edition of this well-known work. The title is a misnomer, since (with Vol. I treating of copper, lead, gold and silver) the treatise is not upon the processes of metallurgy in general, it does not touch on iron or steel at all, and would be properly entitled a treatise on the metallurgy of the non-ferrous metals.

While the work cannot compare in completeness with the special treatise on the separate metals, such as Peters' Copper Smelting, Hofman's Lead, Eissler's Silver and Gold, Ingall's Zinc and Richards' Aluminium, yet on each of the metals just mentioned we are inclined to put Schnabel's discussions in the second place, and regarding the metals, not the subject of these special treatises, we may put Schnabel in the first place.

The 115 pages on mercury needs only the description of the Dennis furnace (our Vol. IV., pp. 104, 463) to make it complete; the 78 pages on tin are the most satisfactory to be found anywhere; the same may be said of the 47 pages on antimony, the 28 pages on arsenic, the 127 pages on nickel, the 29 pages on bismuth, the 19 pages on cobalt and the 17 pages on platinum, although it could have been wished that the latter included the metallurgy of the other platinum-group metals. The 317 pages on zinc are splendidly written, and the 54 pages on aluminium is a great improvement on the chapter in the first edition, but is yet considerably below the standard of the rest of the book.

The book bears the earmarks, in places, of having been uncritically revised by the English translator. Such formulas as $Al_2O_3/2$, taken from a poorly written French article, without change, are an evidence of careless compilation. Prof. Louis has brought the translation well up to date, but his work is not so carefully or critically done as the original body of the treatise, written by Dr. Schnabel.

A suggestion of the kernel of a metallurgical library is to take Schnabel's Allgemeine Hüttenkunde (not yet translated into English) for general metallurgical processes and apparatus, add to it Ledebur's unequaled treatise on Eisenhüttenkunde for the metallurgy of iron (also not yet translated—they both should be), and finish with the two volumes of Schnabel, which Prof. Louis has made accessible to English readers.

The printer and publisher have done their part excellently.

* * *

The Corrosion and Protection of Metals. By A. Humboldt Sexton, F. I. C., F. C. S. Price, $2.00. Manchester: The Scientific Publishing Co.

This small book is composed of notes that "have been written to supply to some extent the need for information" on the important subject of the corrosion and protection of metals. "These notes do not claim to be complete, but rather to represent a preliminary study of the subject." The book certainly does not cover all the work that has been done on this subject, but we can well believe that "its preparation has involved no small amount of labor."

There can be no doubt that more attention must be devoted to this important subject, and it is not surprising that the author complains of the scanty literature on the subject. In this country we may hope that some valuable data may be obtained by the committee on preservative coatings for iron and steel of the American Society for Testing Materials. This committee has appointed various sub-committees, which presented interesting reports at the meeting held at Atlantic City in June, 1905. Prof. Sexton does not expect that the opinions

JUST PUBLISHED

12mo, Cloth 498 Pages Price, $2.50 Net

Van Nostrand's
CHEMICAL ANNUAL
A Hand-book of Useful Data
for Analytical, Manufacturing and Investigating Chemists, and Chemical Students

Based on Biedermanns' "Chemiker Kalender"

EDITED BY

Prof. J. C. OLSEN, A.M., Ph. D.

Polytechnic Institute, Brooklyn
Formerly Fellow Johns-Hopkins University
Author of "Quantitative Chemical Analysis, by Gravimetric, Electrolytic, Volumetric and Gasometric Methods."

With the Co-operation of Eminent Chemists

FIRST YEAR OF ISSUE, 1907.

The absence of a comprehensive reference book of numerical data of the Science, has induced the publishers to undertake the publication of this Annual, which it is their intention to issue, with new data added, annually.

8vo, Cloth 367 Pages Price, $3.00 net

SOLUBILITIES
OF
Inorganic and Organic Substances
A Hand-book of the most
Reliable Quantitative Solubility Determinations

COMPILED BY

ATHERTON SEIDELL, Ph.D. (J.H.U.)

Bureau of Chemistry, U. S. Department of Agriculture

The principal features which have been emphasized in the preparation of this volume are as follows:

Completeness of Data
Uniformity of Expressing Results
Selection of Most Reliable Determinations
Arrangement of Material

RECENTLY PUBLISHED

8vo, Cloth, Illustrated, 298 pages Price, $3.00 net

EXPERIMENTAL
Electrochemistry
Theoretically and Experimentally Treated

BY

N. MONROE HOPKINS, M.Sc., Ph.D.,

Assistant Professor of Chemistry in the George Washington University, Washington, D. C.

Profusely Illustrated with 130 New Drawings, Diagrams and Photographs, accompanied by a Bibliography.

D. VAN NOSTRAND COMPANY
Publishers and Booksellers
23 Murray and 27 Warren Sts., New York

expressed in his book will be unanimously accepted, and probably they will not. If the book, however, stimulates an interest in the subject it will serve a most useful end.

Some recent work done on the subject of corrosion and protection of metals is not mentioned in this book, and this we might call attention to were it not that there is no means of ascertaining when the book was written or published. The omission of the date of publication of books of this kind is irritating.

* * *

Conversations on Chemistry. First Steps in Chemistry. By W. Ostwald.

Part I: General Chemistry; translated by Elizabeth Catharine Ramsey; 12mo., 250 pages, 40 figures. Price $1.50.

Part II.: The Chemistry of the Most Important Elements and Compounds; translated by Stuart K. Turnbull; 12mo., 373 pages, 32 figures. Price, $2. New York: John Wiley & Sons.

"The causes which led me to write this work lie partly in the past, partly in the future. The former spring from the feeling of thankfulness with which I even now regard the 'Schule der Chemie' of Stöckhardt, whose memory still lingers among us. By a stroke of good fortune this excellent work was the first text-book of chemistry which was placed in my hands, and it influenced the whole of my subsequent activity in science. Owing to the carefully thought-out directness in representing the facts to the pupil, the skill in selecting experiments suitable to the physical and mental powers of the beginner, I have never lost touch with experiment, although I have been chiefly occupied with general questions of science. The request of the publishers, who used to issue this work, that I should write a modern Stöckhardt, was both an honor and an opportunity of paying off an old debt of thankfulness."

As regards the future, Ostwald points out that in the hasty development of industrial chemistry in the last decade, it has been almost entirely organic chemistry which has developed in the direction of the discovery of new bodies and their systematic arrangement. But inorganic chemistry was a science before organic chemistry was thought of. Moreover, the processes of inorganic chemistry form the basis of chemical technology, on which that of organic compounds is a superstructure; and the complaint has been made in manufacturing circles that the young chemist trained exclusively in organic chemistry is unfit to cope with the solution of general problems. Ostwald maintains that the remedy must come from general and physical chemistry. It deals with questions which lie at the basis of organic and inorganic, of pure and applied chemistry. It forms a foundation for all real chemical education, and must be regarded as lying at the root of all chemical teaching, especially in its earlier stages.

This fundamental doctrine of Ostwald is hardly disputable. Chemistry and physics are separate sciences only because men, looking in different directions, made them so. A natural phenomenon is a chemical or physical phenomenon according to whether the observer is a chemical or physical specialist. In either case the point of view is one sided. A full view of the phenomenon is obtained only from all sides, i. e., on the basis of physical chemistry. This is most important for industrial work. For the industrial engineer must try to imitate Nature as it is in its complexity, not as it is looked upon by the scientific specialist for special research work, tending in one direction. The earlier the young student understands this truism, the better will be his equipment for later industrial work.

Wilhelm Ostwald is the most brilliant leader of physical chemistry in the world to-day. After having written his voluminous handbooks for the use of his colleagues and advanced students, he now presents this little book to beginners for their first steps in chemistry. Every page shows that the book is a work of love. It also shows Ostwald as an artist.

Being written in the form of a dialogue between master and pupil it may appear to some as somewhat crude art (though admirers of Plato would strongly object to such a conclusion). But it is certain that Ostwald could in this way show more clearly his individual physico-chemical personality, than if the book had been written in form of an ordinary description. The whole arrangement of the matter, the way in which the different principles are introduced, shows Ostwald's individuality. For this reason, besides others, the book should appeal to advanced chemists and teachers as well as to beginners. "For, as I frankly say, it is not for beginners only that I have written this book."

Without Ostwald, physical chemistry would not be what it is to-day. He is responsible for the direction in which the newly united forces of chemists and physicists have proceeded. It is still an open question whether some physical or specifically some electrical viewpoint has not been emphasized too much in the progress which has been made, to the detriment of the chemistry of the subject. It is, therefore, an open question whether Ostwald has not gone too far in emphasizing, for instance, the ionic theory in this text-book for beginners. But we cannot say this without expressing our admiration on the immense amount of information which Ostwald has really embodied in the small space at his disposal, though he has most happily succeeded in preventing the idea that the student now knows everything. The book is full of suggestive hints which should early fill the student "with that longing to pry into the mysteries of science" which constitutes an essential qualification for his future usefulness to science and mankind.

The first volume deals with general chemistry and is divided into thirty chapters: substances, properties, substances and mixtures, solutions, melting and freezing, boiling and evaporation, measuring, density, forms, combustion, oxygen, compounds and constituents, elements, light metals, heavy metals, more about oxygen, hydrogen, oxygen and hydrogen, water, ice, steam, nitrogen, air, continuity and exactness, the expansion of air by heat, the water in the air, carbon, carbon monoxide, carbon dioxide, the sun.

The second volume deals with the chemistry of the most important elements. The first chapters deal with chlorine, preparation and properties, chlorine and water. Then follows a chapter on acids and bases, and the simple neutralization experiments are used as the foundation to introduce the quantitative stoichiometrical laws. The following chapters are: chemical equivalents, the weights of combination, multiple proportions, the atomic theory, the law of gaseous volumes, electrolysis, acids, salts, the oxygen compounds of chlorine, bromine, iodine, sulphur, sulphuric acid, hydrogen sulphide, nitrogen and nitric acid, ammonia, phosphorous, carbon, silicon, sodium, potassium and ammonium, calcium, barium, strontium, magnesium, aluminium, iron, manganese, chromium, cobalt and nickel, zinc, copper, lead, mercury, silver (photography), tin, gold and platinum.

Both translators may be congratulated on the excellent work they have done. It may be added that the book has also been translated or is being translated into Swedish, Russian and Dutch.

* * *

Lehrbuch der Elektrochemie. By Prof. Dr. Max Le Blanc Fourth edition. 319 pages, 25 illustrations. Price, in paper cover, marks 6; bound, marks 7 (retail price in New York, $2.00 and $2.35 respectively). Leipzig: Oskar Leiner.

This book is known as one of the best German books of small size on theoretical electrochemistry on the basis of the electrolytic dissociation theory and the theory of solution. Within eleven years after the appearance of the first edition three further German editions have become necessary, and the book has been translated into English, French and Italian. The author now occupies the chair formerly held by Wilhelm Ostwald in Leipzig.

Volume II, Part III, NOW READY

ALLEN'S

Commercial Organic Analysis

A TREATISE ON THE PROPERTIES, MODES OF ASSAYING, AND PROXIMATE ANALYTICAL EXAMINATION OF THE VARIOUS ORGANIC CHEMICALS AND PRODUCTS EMPLOYED IN THE ARTS, MANUFACTURES, MEDICINE, ETC. WITH CONCISE METHODS FOR THE DETECTION AND DETERMINATION OF THEIR IMPURITIES, ADULTERATIONS, AND PRODUCTS OF DECOMPOSITION.

By ALFRED H. ALLEN, F. I. C., F. C. S.

Past President, Society of Public Analysts; formerly Public Analyst for West Riding of Yorkshire, the City of Sheffield, etc.

Volume II, Part III

Acid Derivatives of Phenols, Aromatic Acids, Resins and Essential Oils

Third Edition

Rewritten and Revised by the Author and

ARNOLD ROWSBY TANKARD, F. C. S.

Member of the Society of Public Analysts

8vo. Cloth, net $5.00

P. Blakiston's Son & Co., Publishers
1012 Walnut Street, Philadelphia

Handbook of Mathematics

FOR ENGINEERS AND ENGINEERING STUDENTS

By J. CLAUDEL

Translated and Edited from the Seventh French Edition by OTIS ALLEN KENYON

A complete book on Mathematics
It covers very thoroughly
Every branch from Arithmetic to Calculus

TABLE OF CONTENTS

Part I.—Arithmetic. I.—Fundamental Operations on Whole Numbers. II.—Properties of Whole Divisors. III.—Fractions and Decimal Numbers. IV.—Powers and Roots. V.—Ratios, Proportions Progressions. VI.—Diverse Rules. VII.—Logarithms. Part II.—Algebra. I.—Of the Four Fundamental Algebraic Operations. II.—Equations of the First Degree. III.—Powers and Roots of the Algebraic Quantities. IV.—Equations of the Second Degree. Part III.—Geometry. Plane Geometry. Solid Geometry. Problems in Geometry. Part IV.—Trigonometry.—Plane. Spherical Trigonometry. Part V.—Analytical Geometry. Part VI.—Calculus. I.—Differential Calculus. II.—Integral Calculus. III.—Applications of Integral Calculus.

Cloth, 708 Pages. 422 Illustrations. Price, $3.50 Net.
Sent anywhere postpaid for the price
Send Us Your Inquiries Write For Our Catalogs

McGraw Publishing Company
PUBLISHERS, IMPORTERS AND BOOKSELLERS
114 Liberty Street, New York

LE CHATELIER-BOUDOUARD-BURGESS—*High-Temperature Measurements.* Second Edition, Revised and Enlarged. 12 mo, xiv + 341 pages, 79 figures. Cloth, $3.00.

LODGE—*Notes on Assaying and Metallurgical Laboratory Experiments.* 8 vo, viii + 287 pages, illust. Cloth, $3.00.

DOLEZALEK-VON ENDE—*The Theory of the Lead Accumulator* (Storage Battery). 12 mo, xi + 241 pages, 30 figures. Cloth, $2.50.

ULKE—*Modern Electrolytic Copper Refining.* 8vo, viii+170 pages, 73 figures. Cloth, $3.00.

JOHN WILEY & SONS
43 & 45 E. 19th St., New York City

NOTES ON

Electrochemistry

By F. G. WIECHMANN, Ph.D.

CLOTH 150 PAGES PRICE $2.00 NET

CONTENTS

I.—General Principles
II.—Electrical Energy
III.—Electrochemistry
IV.—Electrolytic Dissociation
V.—Electro-Analysis
VI.—Electrotechnology

"The principal aim kept in view in the preparation of this book has been the giving of a clear and concise presentation of the general principles which underlie electrochemical science.

"Endeavor has been made to meet the needs of students entering upon the study of electrochemistry and of chemists interested in the application of electrical energy to chemical problems.

"Prefacing each chapter is a bibliography of important treatises bearing upon the subject matter discussed in it."

Postpaid on Receipt of Price

Write for Catalogs *Send Us Your Inquiries*

McGRAW PUBLISHING CO.
Publishers, Importers and Booksellers
114 LIBERTY STREET NEW YORK

A comparison with former editions shows that in its new edition the book has been thoroughly revised and made up to date in many respects without increasing the volume.

It is a pity that an analogous book of equal lucidity, conciseness and completeness does not exist on electrochemical engineering. The man to write it would be, however, an engineer, not a professor.

* * *

Some Founders of the Chemical Industry.—Men to be remembered. By J. Fenwick Allen. 289 pages, 15 portraits. Price, 5s. net (price in New York, $2.00 net). Manchester: Sherratt & Hughes.

The eight biographical sketches of founders of the alkali industry in Lancashire which are collected in this volume, were first published in the *Chemical Trade Journal.* The subjects of the eight sketches are William Gossage, Josias Christopher Gamble, James Muspratt, Andreas Kurtz, Henry Deacon, James Shanks, Christian Allhusen, Peter Spence.

These men were born between 1776 and 1822, they died between 1848 and 1890. We have, therefore, here to do with the history of a past epoch. This is also true in another sense. The story of the life and work of these men is an outline of the individualistic period of the development and growth of the Lancashire alkali trade. Since 1890 the situation has completely changed. This trade has been transformed by the absorption of nearly all the private concerns into the great trust or combine—the United Alkali Co.

It is but natural that there is a decidedly personal element in the stories of this book. These eight men are well worth being remembered and the author has told their life well. The mechanical makeup of the volume is simple and decent.

* * *

Handbook of Mathematics. For engineers and engineering students. By J. Claudel. From the seventh French edition. Translated and edited by Otis Allen Kenyon. 708 pages, 422 illustrations. Price, $3.50. New York: McGraw Publishing Co.

This book is unique in several respects. It covers in a single volume the whole field of mathematics, from the simplest operations on whole numbers to principles and applications of calculus. While print, illustrations and general make-up are excellent the price of the book is exceedingly low. Evidently the publishers expect a very large sale and the book certainly deserves it.

The book has six parts: arithmetic (whole numbers, fractions, powers and roots, ratios, proportions and progressions, logarithms); algebra (fundamental operations, powers and roots of algebraic quantities, equations of the first, second and third degree); geometry (plane and solid); trigonometry (plane and spherical); analytical geometry; calculus (differential and integral calculus with applications).

Aside from its value as a text-book for the class room, the book should be extremely useful as a reference book. Probably every engineer or professional or commercial man in general will agree with the translator that "the use of text-books for reference is discouraging. For example, if a busy man wishes to solve an integral, which is not given in the table, he naturally refers to his college text-book on integral calculus, spends several hours studying, and finds his trouble is farther back, most likely in algebra; then the chances are that, due to lack of time, he will give up and declare that he has forgotten his calculus." In the present volume this trouble has been anticipated by the very frequent use of cross references, completely interconnecting all parts of the book. There is no index.

A special word of praise is due to Mr. O. A. Kenyon. His translation of the French text has faithfully preserved the conciseness, elegance and gracefulness which are so characteristic of the French school of mathematics. But Mr. Kenyon has been equally successful as editor in adapting the French book to the needs of American engineers and engineering students.

Electrochemical and Metallurgical Industry

VOL. V. NEW YORK, MAY, 1907. No. 5.

Electrochemical and Metallurgical Industry

With which is Incorporated Iron and Steel Magazine

Published on the first of each month by the
ELECTROCHEMICAL PUBLISHING COMPANY,
[*Incorporated.*]
114-118 LIBERTY STREET, NEW YORK.

J. W. RICHARDS, PH. D.....*President*
E. F. ROEBER, PH. D.....*Editor*

Subscription Price: $2 per year, postpaid to any part of the world. Single copies 25 cents.

Copyrighted, 1907, by the Electrochemical Publishing Co.

Entered as Second-Class Matter, June, 1903, at the Post-Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, MAY, 1907.

CONTENTS.

EDITORIAL 159
Philadelphia Meeting of the American Electrochemical Society.. 159
Metallurgical Calculations 159
To Every Action there is an Equal and Opposite Reaction..... 159
The Cost and the Price of Copper..... 160
The Open-Hearth Steel Process..... 160
Program of Philadelphia Meeting of American Electrochemical Society 162
The Iron and Steel Market..... 163
Dedication of the United Engineering Societies Building 164
CORRESPONDENCE:
Melting Points of Elements. By Kurt Arndt..... 164
Metallurgical Calculations (Electrometallurgy of Iron and Steel). By J. W. Richards..... 165
The Aussig Glocken Process for Alkali-Chloride Electrolysis. By Otto Steiner 171
A 24-Ton Induction Furnace for Steel Manufacture..... 172
The Use of Graphic Formulæ in Metallurgical Calculations. By David H. Browne 174
The Problems of Bleaching with Paper-Pulp Electrolytic Hypochlorite Solutions. By W. Pollard Digby..... 178
Pierre Eugene Marcelin Berthelot. By Charles A. Doremus 182
The Moore Vacuum-Tube Light and the Luminosity of Gases. By C. J. Thatcher 184
Theory and Practice of Sherardizing. By Alfred Stansfield 187
NOTES ON ELECTROCHEMISTRY AND METALLURGY IN GREAT BRITAIN.. 189
SYNOPSIS OF PERIODICAL LITERATURE..... 191
ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS 194
RECENT METALLURGICAL PATENTS 195
Electricity at Jamestown 197
Works Pyrometer 197
NOTES 197
DIGEST OF UNITED STATES PATENTS..... 199
NEW BOOKS 199
BOOK REVIEWS:
D. Peters' The Principles of Copper Smelting 199
Proceedings of the Chemical, Metallurgical and Mining Society of South Africa. Vol. III 200
A. Minet and L. Waldo's Aluminum 201
H. Danneel and E. S. Merriam's Electrochemistry 202
W. C. D. Whetham's Recent Development of Physical Science 202

Philadelphia Meeting of the American Electrochemical Society

The admirable program which has been arranged for the Philadelphia meeting should give a new strong impetus to the American Electrochemical Society. The professional and social features of the meeting are exceedingly well balanced, while the program of papers to be read and discussed covers such a wide variety of subjects that there should be enough of interest for everybody, be they engineer, scientist or business man. We trust that a very large attendance will be the reply from the membership at large to the call sent out from the old city of Benjamin Franklin.

Metallurgical Calculations

The article on the electrometallurgy of iron and steel, published in our present issue, concludes the second part of Prof. J. W. Richards' Metallurgical Calculations. The first part, which has already appeared in book form, dealt with the general principles of chemical and metallurgical calculations. The second part, which is now concluded, and which will also be soon available in book form, was entirely devoted to the metallurgy of iron and steel. The third part will relate to the non-ferrous metals. The first instalment, to be published in our next issue, will deal with the metallurgy of copper.

To Every Action there is an Equal and Opposite Action

The recent bad break in the prices of railroad and industrial securities on the New York stock market was not altogether unexpected by the average shrewd outside observer. It was largely a panic among rich speculative pools, which have long been discounting possible prosperity and have had no idea that a storm could ever come to a sea for so long time calm. The jar that disturbed the super-saturated solution of prosperity was undoubtedly the attitude of President Roosevelt on the railroad question. But this was an incidental cause, and the real causes were much deeper-seated. Most direct was the attitude of large railway magnates to the public, expressed in such actions as the sudden declaration of an increased dividend for speculative purposes and also in a flippant and breezy unconcern for the rights of the people disclosed in an official investigation. A more far-reaching, if direct, cause is the vast sums tied up by the public in speculative enterprises, as mining companies, real estate ventures and small industries and street railways. These commitments, though often small individually, will total up enormously in the aggregate. They have diverted large streams of investment funds from the financial centers to the smaller bankers and promoters. And it is not without the substance of fact that the investing public are turning for financial advice in distrust from the large men to the smaller ones, whom they know more closely

* * *

One of the further causes is a widespread extravagance of all classes of our people. Had this country the thrifty habits of

France, the ready cash resources of the New Yorker would soon eclipse those of London, Paris and Berlin combined. But it seems impossible with the great influx of money for our people to follow the ways of the habitual saving. Another strong precipitant of market prices of stocks was the increase in the rate of interest. As we have pointed out, the advance in industry, due to modern applied science, has increased greatly the productivity of capital. Hence capital exacts high returns for interest. Interest rates had risen last Fall to such a point that it seemed impossible for stocks to stand at quotations returning only two-thirds of the normal borrowing rate. This year, also, like 1903, was a pre-presidential year, and large retrenchment was in order until our political house-cleaning was over. In several other respects 1907 resembles 1903, and it would be surprising did we not have a recession in business in the Summer and Fall somewhat analogous to the recession in 1903. We are inclined to think that this will be much less serious, for the diffusion of accurate financial intelligence is much better now than then. Prices of commodities are now much too high, especially of copper and lead, and these must be reduced to a normal basis. The action of the United States Steel Corporation in keeping the prices of its products 8 per cent below those of 1902 was extremely wise, for the reaction will be less. Taken in its entirety, the financial and business situation exhibits no distressing symptoms. This country is growing richer very fast—possibly as fast in times of recession as in a boom. As we remarked before, every sane man is a bull on America's industrial future if the future be deferred long enough.

The Cost and the Price of Copper

In valuing the ore reserves of a mine, a certain set price must be put on the recovered metal after deductions are made for metallurgical losses, cost of mining, freight and treatment. As the development of a mine should be a commercial proposition, it is necessary to make some accurate forecast of the average price of a metal for some future period. This should be based on the average cost of production of the largest producers with proper allowances. In order to induce capital to embark in a mining enterprise there should be a large profit on the "turn-over." What this figure should be is impossible to state, for there is no psychological balance to weigh human avarice. But reasoning on the facts, it would appear that 50 per cent is a fair approximation. That is, a mining and smelting business, doing on the average a business of $12,000 a day, should net $4,000 a day. The profit on the investment, of course, is much less, for there is a monopolistic value given to the mine which forces this down to about 10 or 12 per cent.

* * *

To get the base figure for the cost of copper we can be sure that in 1902 and 1903 very few of the big copper companies were making much money at 11-cent copper. Most of them were paying dividends, but these were often really partly paid out of the capital, for sufficient was not spent in new work. By an accurate system of accounting this was really paid out of capital. In the past five years advances in the art of metallurgy have possibly slightly decreased the cost of making copper. The advantage so gained would have been larger had not the price of labor and supplies risen greatly. Probably on the average the cost of producing copper and transporting it to New York is now in the Butte district slightly over 9 cents per pound. In the Michigan copper mines the figure is a little higher, probably 9½ cents to 10 cents per pound. In Arizona the cost is much less, and hardly averages more than 7½ cents. One large copper mine of Mexico that formerly made copper for 7 or 8 cents, had a cost of 14 cents. This, however, was due to gross mismanagement.

* * *

When freight, commissions, refining charges and development work are taken into consideration we believe that 10 cents is a fair average figure for bed-rock cost of "laying down" in New York refined ingot copper. Allowing 50 per cent profit on the cost of production, but none too high for the mining business, we have an average New York price for the future of 15 cents per pound. This is a round number which is conservative for estimates on the value of ore reserves. It is, however, not improbable that future development of the electrical industry, especially the electrification of the great railroad systems of America, will give at times an artificially high value, because the demand occasionally may increase faster than the means of supplying this demand. It would appear that the copper market has just passed through one of these periods of abnormally high prices and is liable now to return to a figure more equitable alike to producer and consumer.

The Open-Hearth Steel Process

The open-hearth steel statistics just presented by the American Iron and Steel Association show a production in 1906 of 10,970,998 gross tons of ingots and castings. The record of production is shown below, beginning with 1896, the first year for which separate statistics for the basic and acid processes were ascertained:

United States Production of Open-Hearth Ingots and Castings, Gross Tons.

	Basic.	*Acid.*	*Total.*
1896.....	776,256	522,444	1,298,700
1897.....	1,056,043	552,628	1,608,671
1898.....	1,569,412	660,880	2,230,292
1899.....	2,080,426	866,890	2,947,316
1900.....	2,545,091	853,044	3,398,135
1901.....	3,618,993	1,037,316	4,656,309
1902.....	4,496,533	1,191,196	5,687,729
1903.....	4,734,913	1,094,998	5,829,911
1904.....	5,106,367	801,799	5,908,166
1905.....	7,815,728	1,155,648	8,971,376
1906.....	9,649,385	1,321,613	10,970,998

It would not be easy to find a parallel to the record shown above. In not one year has the production of open-hearth steel shown a decrease, while the production of basic steel has advanced very rapidly. Production by the acid process has less steadily increased, having taken backward steps in 1900, 1903 and 1904, the 1902 record not being broken until 1906. In 1896 nearly as much steel was made by the acid as by the basic open-hearth process; in 1900 there was only one-third as much; in 1906 there was less than one-seventh as much.

* * *

Three causes have chiefly contributed to the growth of the basic relative to the acid open-hearth process. In the first

place, better steel is being made, in the circumstances, now than formerly. If we may be pardoned for the expression the basic open-hearth furnace was at first hailed chiefly as a good thing in which to utilize junk, now it is a means of making steel. The amount of junk available has not increased nearly as rapidly as has the output of steel, better pig iron, on the average, is being used, and much of the scrap used is of the finest quality, being new material. This scrap is, in a sense, made for the purpose, a fact we shall recur to later. In the second place, engineers have quite largely learned to call for steel rather than processes. It is quite certain that a few years ago many engineers were specifying against basic steel merely because they were doubtful of their own ability to specify, purely on chemical and physical grounds, for the quality they desired to be furnished them. Now they are able to define what they want in a more scientific way. In the third place, Bessemer pig iron, which must be used in the acid open-hearth process, is growing scarce, while there is plenty of basic pig, low in phosphorus relative to the basic pig at first employed, but still outside the Bessemer limit of 0.10.

* * *

The knowledge of how largely old material was employed in the basic open-hearth furnace in its early years, through the late nineties, the charges running up to 80 per cent scrap in many cases, and that the outcome of old material has quite fallen short of equaling the rapid increase in basic open-hearth steel ingot production, while various processes have been adopted which are claimed to eliminate the need for scrap, does not lead to an understanding of the statistics of basic open-hearth steel ingot production proportionate to the production of basic pig iron. In 1896 the production of basic pig iron constituted 43.3 per cent of the production of basic open-hearth steel ingots; in 1897 the percentage was 52.7 per cent, the highest shown; it fell to 40.0 per cent in 1901, and has since then increased again, being 48.6 per cent in 1904, 52.5 per cent in 1905 and 52.1 per cent in 1906. At one time Bessemer pig iron was used to a small extent in this process, but it is not so now, and the limited quantities of charcoal pig iron used are negligible. With the relatively reduced quantity of old material available, and the use at many plants of the so-called non-scrap processes, why is almost double as much steel produced as pig iron?

* * *

The statistics of Bessemer and open-hearth steel ingot and casting production are correct, in their way, but they are strictly what they are stated to be, and nothing else. Neglecting the comparatively small tonnage of castings included, they are the statistics of the production of steel ingots. They are not really statistics of the production of steel at all. To the lay mind a steel ingot is made merely that it may be rolled into a finished product for the market, with a loss in scale and scrap which the manager, dealing with a valuable material, will endeavor to keep down to the lowest proportion. To the manager, however, the steel ingot is produced as something from which he can select a portion to roll into finished product and sell, leaving a large portion to go into the open-hearth furnace. The bulk of the Bessemer steel scrap does not return to the converter, but goes to the open-hearth furnace, while in a sense the open-hearth material is making round trips from the furnace to the shear and back again. Between the statistics of ingot production and the statistics of rolled steel production there is a gap which is bridged by scrap, not made as a necessary incident to the rolling, but as a necessity to the production of good steel, and a convenience to the open-hearth furnace.

* * *

The 1905 statistics shows a production of ingots (excluding castings) of 10,919,272 gross tons by the Bessemer process, 8,444,836 tons by the open-hearth process, and 99,072 tons by the crucible and other processes, making a total of 19,463,180 gross tons of steel ingots, while the total production of all rolled steel was reported at 14,780,025 gross tons, leaving a spread of 4,683,155 tons. In that year the difference between basic pig iron and basic ingot and casting production was 3,700,000 tons; a large part of this was made up of scrap figuring in the above tonnage. Another and smaller part was, of course, made through the use of ore. It is well, therefore, to remember that the statistics of ingot production are literally that, and not statistics of steel production. In no current literature do we ever see this distinction made, yet it is a most important one, seeing that the difference now runs into millions of tons. Strictly speaking, steel is produced when the necessary elimination of impurities, whether in pig iron, ore or scrap, has been made. It is not altogether making steel to pour an open-hearth heat, cast it in ingots, weigh the ingots, and then send a considerable part back to the furnace, nor is it altogether making steel to cast a Bessemer ingot, cut part of it off, melt it over again in an open-hearth furnace and then weigh the second ingot of which it makes part.

* * *

So, in a measure, the open-hearth steel statistics with which we are dealing are misleading. The ingot and casting statistics for 1906 show 12,275,253 gross tons attributed to the Bessemer and 10,970,998 tons attributed to the open-hearth process; the actual work of the two processes was not in this proportion, nor was the total tonnage of finished steel actually produced and sold at all commensurate with these figures. These are really merely the records of the ingot scales. Incidentally, we are inclined to think those scales are hardly as accurate as those whose records go to the invoice clerks. While sight must not be lost of the fact that these open-hearth steel ingot figures are very generally misunderstood, it is true that the basic open-hearth process is growing rapidly. The open-hearth ingot and casting figures for 1906 show but 1,304,255 gross tons less than the Bessemer figures. Last month we noted that the Bessemer production has stopped its rapid growth, and will in future grow but slowly if at all. The open hearth process, on the other hand, continues to grow rapidly. Without attempting to catalogue all the new erection of open-hearth furnaces, it may be remarked that the United States Steel Corporation is now building 18 furnaces at Duquesne, 12 at Youngstown and 50 at Gary, Ind., a total of 80 furnaces at three points. These furnaces are rated at 50 to 60 tons capacity, and will make, using direct metal, 16 to 18 heats per week, or 75,000 to 80,000 tons of ingots per week, or not far from 4,000,000 tons per year. As they will come in at intervals during the latter part of this year and early next year, they will easily swing the preponderance, in point of ingot tonnage, from Bessemer to open-hearth, giving the open hearth process a greater lead over Bessemer in 1908 than the latter had over open-hearth in 1906.

Program of Philadelphia Meeting of American Electrochemical Society.

The official programme of the seventh general meeting of the American Electrochemical Society, to be held in Philadelphia on May 2, 3 and 4, is so very attractive that the evidently great efforts of the local committee should be rewarded by an unusually large attendance.

The meetings will be held at the University of Pennsylvania, in the Lecture Theater of the John Harrison Laboratory of Chemistry, at the northeast corner of Thirty-fourth and Spruce Streets. The headquarters for registration will be in the same building, where members and guests introduced by members will receive badges.

The first meeting will be opened on *Thursday* morning, May 2, at 10 A. M., by an address of welcome by Dr. Edgar F. Smith, vice provost of the University of Pennsylvania. At the following business meeting the reports of officers and directors will be presented and the retiring president, Mr. Carl Hering, will then read his presidential address. Then follows a professional session, devoted to the reading and discussion of papers. The meeting will adjourn at 1 P. M. Luncheon will be served at Houston Hall on the University grounds, the University being hostess.

In the afternoon, at 2 P. M., an inspection will be made of the chemical and the engineering laboratories of the University of Pennsylvania. At 3 P. M. the United Water Improvement Co., Thirtieth Street, below Locust, will be visited, where the commercial production of ozone for water purification will be shown. This is to be followed by a visit to the plant of the John F. Lewis & Bros. Co., where the manufacture of white and red leads will be shown. The factory is at 2570 East Thompson Street. For the evening of Thursday a theater party has been arranged at the new Keith's Theater in Chestnut Street.

On *Friday*, at 9:30 A. M., the second session, devoted to the reading and discussion of papers, will be held. At 1 P. M. the members and guests will meet at Chestnut Street wharf on the city fireboat "Ashbridge," for a private trip on the Delaware River, tendered to the members of this Society by the city of Philadelphia, through the kindness of the Honorable Mayor and the Director of Public Safety. The boat will leave at 1 P. M. sharp, arriving at Tacony at about 1:50, where the party will visit the Disston Saw Works, at which the Colby electric induction furnace for smelting steel is expected to be shown in operation. Thence to the Lardner's Point Pumping Station, where very large pumping engines will be shown. Thence to the Frankford station of the Philadelphia Electric Co., where Mr. C. J. Russell will show working models of the following electric furnaces: The Colby induction furnace, the Héroult type of furnace, an annealing and tempering furnace with fused barium chloride and a melting furnace using kryptol.

Return to the boat at 3 P. M. sharp, thence down the Delaware, passing the Philadelphia and Camden water fronts with all their large industries, including Cramp's ship yard, the New York Shipbuilding plant, the By-Product Coke Ovens, sugar refineries, League Island Navy Yard, etc., and arriving at Gloucester at 4 to 4:30 P. M., to visit the Welsbach Light Co's works, where the manufacture of mantels and other interesting processes will be shown.

After having met again on the boat, at 5:45 P. M., the party will arrive at Washington Park at 6, where the landing of the shad nets may be seen, which will be followed, in fine Philadelphia style, at 7:30 P. M., by a planked shad dinner. This informal dinner will take the place of the usual banquet.

On *Saturday* morning, May 4, 9:30 A. M., the third session, devoted to the reading and discussion of papers, will be held. The meeting will adjourn at 12:30. Then follows a demonstration of exhibits. There will be an exhibition of apparatus of special interest to electrochemists in the Lecture Theater of the Chemical Laboratory. These exhibits will be open for inspection during the whole meeting, but the demonstrations will take place after the Saturday session. At 1:30 P. M., the members and guests will take lunch at Houston Hall, as guests at the University.

In the afternoon a visit will be paid to the United States Mint, at Seventeenth and Spring Garden Streets. Here the electrolytic processes for the refining of gold and silver will be shown under the direction of Dr. D. K. Tuttle and Mr. Leonard Morgan. The party will divide into groups of not more than ten to fifteen.

The following papers will be presented at the three sessions. *Thursday* morning session, immediately after the presidential address of Mr. Carl Hering:

1. Some Efficiency Considerations of an Electrolytic Cell, W. R. Mott.
2. Changes of Concentration and Migration Velocities, C. J. Reed.
3. The Work Done in Electrolysis, J. W. Richards.
4. The Present Status of the Thermodynamic Scale, E. Buckingham.
5. Determination of Fixed Points in Pyrometry, G. K. Burgess.
6. Bomb Calorimeter for Measuring the Heat of Combustion of Substances Giving Solid Oxidation Products, Henry Noel Potter.
7. On the Density, Electrical Conductivity and Viscosity of Certain Fused Salts and Their Mixtures, H. M. Goodwin and R. D. Mailey.
8. Electrolytic Pickling of Steel, C. J. Reed.
9. Electric Reduction of Titaniferous Iron Ore, Gustave Gin.
10. Recent Developments in Electrolytic Analysis, E. F. Smith.

Friday morning session:

11. Illustrated lecture by invitation of the Board of Directors, by Dr. C. P. Steinmetz, on the Conductions of Vapors and Gases.
12. The Electro-Metallurgy of Zinc and Its Relation to the Present Practice, W. McA. Johnson.
13. Electrodeposition of Zinc, R. C. Snowdon.
14. A Practical Limitation of Resistance Furnaces; the "Pinch" Phenomenon, Carl Hering.
15. The Action of Carbon on Magnesia at High Temperatures, O. P. Watts.
16. Reply to paper by E. A. Sperry, "Electrochemical Processes as Station Load Equalizers," Trans. IX., 147, John Meyer.
17. Relative Cost of Power, Charles E. Lucke.
18. Surface Properties of Aluminium and Zinc, W. J. Hammer.
19. The Helion Lamp, H. J. Parker.

Saturday morning session:

20. Electrolytic Corrosion of Brass (1906 award), A. T. Lincoln.
21. Rapid Determination of Electrolytic Resistance, C. F. Burgess.
22. C. F. Burgess (title to be announced).
23. Polarization Voltages of Silver Nitrate Solutions, J. A. Wilkinson and H. A. Gillett.
24. The Electrolytic Deposition of Nickel-Zinc Alloys, E. P. Schoch and Alcan Hirsch.
25. A closed Electric Furnace for Reducing and Distilling Metals from Their Ores, E. R. Taylor.
26. Evolution of Modern Methods of Parting and Refining, D. K. Tuttle.
27. Granular Carbon Resistance Furnace, S. A. Tucker.
28. Electric Tube Furnace for Temperature Measurements, S. A. Tucker.
29. Influence of Strain on the Corrosion of Iron, W. H. Walker.

30. On Carbon for Electrometallurgy, F. A. J. FitzGerald and J. Forssell.

31. The Titanium Arc, R. Fleming.

The executive local committee consists of Dr E. F. Smith, chairman; Mr. Carl Hering, vice-chairman, Mr S. S. Sadtler, 39 South Tenth Street, Philadelphia, secretary; Mr. George Breed and Dr. J. W. Richards.

The chairman on the committee on excursions is Dr. J W Richards; the chairman of the entertainment committee, Mr George Breed; the chairman of the University committee, Dr. E. F. Smith.

The ladies' committee consists of Mrs. George Breed, Mrs C J. Reed, Mrs. J. W. Richards, Mrs. S. S. Sadtler, Mrs P. G. Salom and Mrs. E F. Smith

The Iron and Steel Market.

Developments in the trade in April have been quite in line with the views expressed in last report, that the near future of the market is entirely assured of satisfactory conditions, while the two or three closing months of this year, and the entire year 1908, are more or less in doubt. It does not follow that there is assurance of even the mildest kind of a depression in 1908; usually the iron trade cannot see so far ahead; occasionally it can, but it happens that this is not one of the occasions.

There has been a continuance of heavy specifications in all finished steel products, according to all accounts, and the guarantee of full activity for all the mills through the year is questioned only by those who profess to see a much greater willingness than usual on the part of producers to take the public into their confidence as to the state of their order books.

Pig iron for second half delivery has strengthened during the month, some large purchases of steel-making pig being made for second-half delivery, while, a matter of still more importance, some consumers who were already covered through the third quarter have come into the market and bought fourth-quarter iron at full prices.

The statistics of open-hearth steel production in 1906 were announced about the middle of the month, and showed a total production of ingots and castings of 10,970,908 gross tons, of which 9,649,385 tons were made by the basic and 1,321,613 tons by the acid process, a gain in open-hearth steel over 1905 of practically 2,000,000 tons, the second largest gain, in point of tonnage, ever shown in one year by the open-hearth process.

No important change in prices of finished steel products has occurred during the month; iron bars are slightly lower, pig iron is stronger and billets for Pittsburg delivery are higher

Pig Iron

Furnaces early in the month receded from their position of demanding $21.50, valley, for second-half Bessemer making light sales at $21.00, valley. This move did not encourage a waiting policy, as such moves usually do, but was followed by heavier sales at this price, and the market has become thoroughly established on Bessemer and basic at $21.00, valley, for any delivery during the second half, with prospects that regular consumers will easily absorb all the available tonnage, leaving none for such occasional buyers as the United States Steel Corporation, which buy only to supplement their own production or to support the market. Among Bessemer sales during the month were the following: Two contracts aggregating about 70,000 tons on the sliding scale basis, over half of this being in one contract for second-half delivery, the balance on a contract for twelve months beginning with April; 157,000 tons to the Youngstown Sheet & Tube Co., being 10,000 tons for June at $22.00, valley, and 147,000 tons for second half at $21.00, valley, 122,000 tons being furnished by the Bessemer Furnace Association, 15,000 tons by the United Iron & Steel Co. (which recently absorbed the Cherry Valley properties), and 10,000 tons by the Andrews & Hitchcock Iron Co., 2,500 tons for third quarter and bought later by the same interest, 2,500 tons for fourth quarter, at $21.00, valley, and various lots aggregating perhaps 10,000 tons for deliveries in the second quarter at $22.50 to $23.00, valley. Sales of basic included 1,500 tons for third and 5,000 tons for fourth quarter, bought at different times by one consumer, at $21.00, valley, and a sliding scale contract covering a small monthly tonnage for a period of months. In foundry iron, sales have been lighter. Some Buffalo furnaces are reported to have sold for the first quarter of 1908 at good prices; Eastern and valley furnaces have sold moderate tonnages for second half, the Eastern furnaces at slightly lower prices than they had been asking, and the valley furnaces at slightly higher prices than could have been done a month earlier. The middlemen who were offering Southern iron for second half at $18.00, Birmingham, presumably with the connivance of the furnaces, who were themselves asking $18.50, have withdrawn, and the Southern market is firm at $18.50 for second half. The 25-cent advance in freight rates to the Ohio River finally went into effect April 1, so that delivered prices, on an $18.50 basis, are $21.75, Cincinnati; $23.35, Pittsburg, and $22.85, Chicago. In the valleys No 2 foundry for second half is pretty firm at $22.00, valley, or $22.85, Pittsburg or Cleveland. For any delivery prior to July furnaces are obtaining premiums of from $1.00 to $3.00 a ton.

Steel.

No billets are obtainable from Pittsburg producers there requiring all their product for their own finishing mills, and the Pittsburg market is the price f. o. b. other points which are offering, plus the freight. For instance, a sale of 1,000 tons of Bessemer billets was made at about $29.50 f. o. b. Youngstown, or about $30.50, delivered Pittsburg, and a sale of open-hearth billets at about $31.70, Pittsburg, the steel coming from a point taking a freight rate between $1.50 and $2.00. Sheet bars are nominally $30.00 f. o. b., Pittsburg or Youngstown, but for prompt delivery mills are endeavoring to obtain $31.00, while it is reported a prominent consumer bid $30.00, mill, for 15,000 tons for fourth quarter without obtaining the material.

Rails.

It is reported that the Tennessee Coal, Iron & Railroad Co. has sold 46,000 tons of open hearth rails for 1908 delivery at $30.00, Birmingham. For 1906 delivery this company sold its rails at $28.00, Birmingham, the same price, f. o. b. mill, as is obtained for Bessemer rails; for 1907 it made an advance of $1.00 a ton, and if the present report is correct another dollar advance has been made. Open-hearth rails might, perhaps, properly command an advance of $2.00 a ton over Bessemer rails, but as the Tennessee company's sales are made to contiguous roads, which otherwise would have to buy Bessemer at $28.00, f. o. b. Pittsburg or Chicago, the roads are really not paying so large a premium for the open-hearth product. Nothing is known as to what the United States Steel Corporation will do in the matter of open-hearth rail prices. About January next it will be able to make open-hearth rails at Youngstown, and soon thereafter should begin operations at Gary. The reticence in this matter gives rise to an idea that the price will be governed by commercial considerations rather than considerations of the actual relative value of Bessemer and open hearth rails. Orders are now being booked for 1908 delivery of Bessemer rails.

Finished Steel

Specifications have been heavy in all lines, but there has not been a great deal of new buying. Some contracts for shapes, bars, plates etc., expired April 1 and have not been renewed, but there were heavy unfilled specifications against them. The agricultural implement makers, not being given any concession for their annual contracts on steel bars from July 1, as was done a year ago, have refrained from contracting, but still

large tonnages due them. Plates can be had from some of the smaller mills for early delivery at less than former premiums, but the large mills, which sell only at the regular price, are filled up farther ahead than formerly. Structural business is improved, mills having specifications on books for solid runs of from two to three months. Regular mill prices, on which premiums are frequently charged for early delivery, remain as follows:

Structural shapes, $1.70 for beams and channels, 15 inches and under, angles and zees; $1.75 for tees; $1.80 for beams and channels over 15 inches.

Plates, $1.70 for tank quality, ¼ inch and heavier, 100 inches wide and less; flange, $1.80.

Merchant steel bars, $1.80, base.

Common iron bars, $1.80, delivered Pittsburg; $1.65, f. o. b. Pittsburg, for Western delivery; these prices have been shaded occasionally in the past month.

Sheets, 28 gauge, $2.60 for black, $3.75 for galvanized.

Tin plates, $3.90 for 100-pound cokes.

Dedication of the United Engineering Societies Building.

The dedication exercises of the monumental and beautiful United Engineering Building took place on April 16 and 17, according to the program which was given in full in our last issue. In connection with these dedication exercises, meetings were held by the three founder societies, the American Institute of Electrical Engineers, the American Institute of Mining Engineers and the American Society of Mechanical Engineers.

The Engineering Societies Building is located on West Thirty-ninth Street, New York, north side, between Fifth and Sixth Avenues. The frontage is 125 feet, the depth 90 feet. The land has been bought with money brought up by the three founder societies, the cost being $502,000, while for the erection of the building, Mr. Andrew Carnegie had given the sum of $1,500,000. The holding corporation is the United Engineering Society, which acts as trustee for the three founder societies.

The building is 13½ stories high. The exterior is built of limestone up to the auditorium floor, and of gray mottled brick and terra cotta above. On the first and ninth floors passages connect the building with the new club house of the Engineers' Club.

The first floor contains the main foyer, writing room, smoking room, etc. Immediately above it is the coat room. The main auditorium, which is exceedingly handsome and fully meets all requirements, extends through the third and fourth floors. On the fifth and sixth floors there are seven smaller lecture rooms.

The seventh and eighth floors have been reserved for the "associated societies," among which are the National Electric Light Association, the New York Electrical Society, the Society of Naval Engineers and Marine Architects and others. The next three floors are occupied by the three founder societies—the ninth floor by the American Institute of Mining Engineers, the tenth by the American Institute of Electrical Engineers, and the eleventh by the American Society of Mechanical Engineers. Finally, the twelfth and thirteenth floors contain the libraries of these three founder societies. They form the nucleus of what is expected to become the greatest engineering library of the world.

On the first day of the dedication exercises, Tuesday, April 16, Mr. Charles W. Hunt was the presiding officer. Congratulatory letters from President Roosevelt and President Diaz of Mexico were read. Mr. Charles F. Scott gave an outline of the history of the building, Mr. E. E. Olcott spoke for the United Engineering Society, after having received the key of the building.

Then spoke Mr. Carnegie. He emphasized the need of co-operation as the keynote of universal brotherhood. He expressed his conviction that the world is getting better every day. To-day is better than yesterday. To-morrow will be better than to-day. So there is no need to worry for the future.

The closing address of the day was made by President Arthur T. Hadley, of Yale, on the professional ideals of the twentieth century. "A hundred years ago we might have had a building in honor of theologians, of lawyers or of physicians." In the twentieth century the engineers got their home. "Yours is the proud boast of having in one brief century established a science as the arbiter of the material affairs of mankind, and of having enforced her worship upon a world once reluctant but now gloriously admiring." What then is still to be done? "It is not enough to have technical training. It is not enough to know the special sciences on which the practice of a profession is based. A man ought to have clear conceptions of the public service which his profession can render, and the public duty which its members owe. Thus, and thus only, can the engineer, the lawyer, the physician, or a member of any of the learned professions rise to the full dignity of his calling." Besides the technical standard there is the ethical standard and professional men must learn to live up to the latter as well as to the former. On the evening of Tuesday a reception was held which was exceedingly well attended.

At the exercises of Wednesday, Mr. John W. Lieb, Jr., presided, and the three presidents of the founder societies, Dr. Samuel Sheldon, Dr. F. R. Hutton and Dr. John Hays Hammond, delivered addresses.

Then followed a great many representatives of institutes of learning and engineering societies in this country and abroad. Mr. T. C. Martin, as president of the Engineers' Club, made a hit by presenting the greetings from the club in a clever little poem: "To our fellow engineers, who've been looking many years, up-town and down, for a home whose rental wasn't high; we members of the club, which has also felt the rub, bring greetings from our little house nearby." He invited all to come over "when weary of the jargon of 4pi and of argon," for "in the club we are human, not forgetting there is woman." The "little house" is the magnificent new building of the Engineers' Club, which has also been donated by Mr. Carnegie.

CORRESPONDENCE

Melting Points of Elements.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—The table of melting points of elements in your February issue, page 48, contains some errors.[1]

According to the latest investigation of Holborn and Valentiner (Annalen der Physik, Vol. 22, 1907, pp. 1 to 48) the melting point of platinum is 1,790° C. The value 1,710° which has heretofore been considered to be the correct one, was based on an erroneous exterpolation for the thermo-couple. Thus we have now come back approximately to the old value found many years ago by Violle.

The figure 800° for magnesium is all wrong; it melts at 633° (Heycock and Neville, 1895).

The latest investigation of Holborn and Valentiner has also given an exact value for the melting point of palladium. It is 1,575°.

Of less importance are the following points: Calcium, 800° (not 760°); nickel, 1,484° (not 1,427°); tin, 241° (not 224°).

It is a pleasure for me to state here that your journal has won a great many friends in Germany. Kurt Arndt.

Technische Hochschule, Berlin, Germany.

[1] See also page 76 of our March issue.—Editor.

Metallurgical Calculations.

By J. W. Richards, Ph. D.

Professor of Metallurgy in Lehigh University.

The Electrometallurgy of Iron and Steel.

Electrical methods may enter into the extraction of a metal from its ores either as electrolytic or as electrothermal processes. Electrolytic processes are those in which the electric current is used for its electrolytic action, *i. e.*, for its electrical decomposing and depositing properties; electrothermal processes are such as use the current merely as a source of heat, to furnish the sensible heat and high temperature necessary for melting materials or for bringing about chemical reactions. So far electrolytic processes have entered the metallurgy of iron only as used by Burgess for electrolytically refining nearly pure iron in an aqueous electrolyte and depositing chemically pure iron; the electrolysis of fused iron salts has not been practically utilized. Up to the present, electrothermal processes are in commercial use for melting together wrought iron and cast iron to make steel, also for keeping cast iron melted while its impurities are being extracted by oxidation; the electrothermal reduction of iron ores to cast iron has been proved technically possible, and may in some places prove commercially practicable.

Electrothermal Reduction of Iron Ores.

If the electric current is used to furnish the heat energy necessary to reduce iron ore, it cannot displace the reducing agent-carbon. In ordinary blast furnace practice the carbon is first burned to provide the heat necessary to smelt down the pig iron and slag, and the product of this incomplete combustion—CO—abstracts oxygen from the ore. The two equations are practically:

At the tuyeres—

$$30C + 15O^2 + 57.15\ N^2 = 30CO + 57.15\ N^2$$

Reduction:

$$4Fe^2O^3 + 30CO + 57.15\ N^2 = 12CO^2 + 18CO + 57.15\ N^2 + 8Fe$$

These equations show us that to produce $8Fe = 448$ parts, $30C = 360$ parts of carbon is the minimum necessary, which is first burned to CO at the tuyeres, and then the producer gas thus formed (N^2 and CO) reduces the iron oxides above. If the heat for fusion is furnished electrically, the first combustion is unnecessary, all blowing in of air is dispensed with and the reaction taking place is:

$$14Fe^2O^3 + 30C = 12CO^2 + 18CO + 28Fe$$

And we have $28\ Fe = 1{,}568$ parts reduced by $30C = 360$ parts, a consumption of less than one-third as much carbon as is required in the blast furnace. The operation consists, therefore, in mixing iron ore and carbon so that for every part of iron present about 0.25 parts of carbon is present, using the proper quantity of limestone or other material to flux the gangue of the ore to a fusible slag, and then furnishing electrically the heat necessary to cause the chemical reaction, melt down the resulting iron and slag, and supply radiation losses. The gases resulting from this electrical reduction are combustible, just as the gases from the blast furnace, and since there is no blast to be heated they can very well be utilized to preheat the charges coming into the furnace, and thus save some of the electrical energy needed.

Problem 73.

A magnetite ore contains:

	Per Cent.		Per Cent.
Fe^2O^3	60.74	MgO	5.50
FeO	17.18	P^2O^5	0.04
SiO^2	6.60	S	0.57
Al^2O^3	1.48	CO^2	2.05
CaO	2.84	H^2O	3.00

It is to be mixed with pure carbon (charcoal fines) and a suitable flux; the fixed carbon being 0.25 per cent of the iron present; the flux silica sand, so as to make a slag with 33 per cent of SiO^2. Neglect the ash and assume 10 per cent of moisture in the charcoal. Assume also:

(a) The pig iron to contain 4 per cent C. 3.5 per cent Si, 92.4 per cent Fe.

(b) The slag and pig iron to contain at tapping 600 and 400 Calories of heat respectively.

(c) The heat losses by radiation, etc., to be 30 per cent of the total heat requirement of the furnace.

(d) The hot gases to escape at 300° C.

(e) The iron to be completely reduced into the pig iron.

(f) The sulphur to go entirely into the slag as CaS.

Requirements:

(1) The weights of ore, flux and charcoal dust needed per 1,000 kg. of pig iron produced.

(2) A balance sheet of materials entering and leaving the furnace.

(3) A heat balance sheet of the furnace.

(4) The number of kilowatt days of electrical energy required per metric ton of pig iron produced.

Solution:

(1) The ore must supply 924 kg. of iron. But 100 parts of ore contains iron as follows:

		Kg.
In Fe^2O^3	$60.74 \times 112/160$	$= 42.52$
In FeO	$17.18 \times 56/72$	$= 13.36$
	Sum	$= 55.88$

Ore required per 1,000 kg. of pig iron:

$$924 \div 0.5588 = 1{,}654 \text{ kg.} \qquad (1)$$

The slag-forming ingredients from this amount of ore are as follows:

		Kg.
Al^2O^3	$1{,}654 \times 0.0148$	$= 24.6$
MgO	$1{,}654 \times 0.0550$	$= 91.0$
CaO	$1{,}654 \times (0.0284 - 0.0057 \times 50/32)$	
	$= 1{,}654 \times 0.0184$	$= 30.4$
SiO^2	$(1{,}654 \times 0.0660) - (35 \times 60/28) = 109.2 - 75$	$= 34.2$
CaS	$1{,}654 \times (0.0057 \times 72/32)$	$= 21.2$
	Sum	$= 201.4$

If x parts of SiO^2 sand are added to these, the total weight of slag will be $201.4 + x$, of SiO^2 in it $34.2 + x$. And since the SiO^2 is to be 33 per cent of the weight of slag, then

$$34.2 + x = 0.33\ (201.4 + x)$$

whence $x = 48$ kg. (1)

The charcoal dust used must contain fixed carbon equal to 0.25 of the iron present, *i. e.*,

$$924 \times 0.25 = 231 \text{ kg.}$$

And since it is 90 per cent fixed carbon the dust required is

$$231 \div 0.90 = 257 \text{ kg.} \qquad (1)$$

Charges.		*Pig Iron.*		*Slag.*		*Gases.*	
Ore	1654 Kg.						
Fe^2O^3	1004.6	Fe	703.2			O	301.4
FeO	284.2	Fe	221.0			O	63.2
SiO^2	109.2	Si	35.0	SiO_2	34.2	O	40.0
Al^2O^3	24.6			Al_2O_3	24.6		
CaO	46.9			CaO	30.4	O	4.7
MgO	91.0			MgO	91.0		
P^2O^5	0.6	P	0.3	Ca	11.8	O	0.3
S	9.4			S	9.4		
CO_2	33.9					CO_2	33.9
H^2O	49.6					H_2O	49.6
Flux	48 Kg.						
SiO^2	48.0			SiO_2	48.0		
Charcoal	257 Kg.						
C	231.0	C	40.0			C	191.0
H^2O	26.0					H_2O	26.0
	1950.0		999.5		249.4		710.1

(3) Heat available is the heat of oxidation of carbon plus that furnished by the electric current. The charge gives up to the carbon, as shown on the balance sheet, 301.4 + 63.2 + 40.0 + 4.7 + 0.3 = 409.6 kg. of oxygen. The 191 kg. of carbon burned would take 191 × 16/12 = 254.7 kg of oxygen to burn it to CO, leaving 154.9 kg. of oxygen to burn CO to CO^2. This would burn 154.9 × 28/16 = 271.1 kg. of CO to CO^2.

The heat of formation of the slag may be taken as approximately 150 Calories per kg. of contained SiO^2 + Al^2O^3. The heat of combination of carbon with the iron is a doubtful quantity, which may be taken at 705 Calories per kilogram of carbon. The formation of CaS gives 2,947 Calories per kilogram of sulphur.

Letting the heat furnished by the electric current = x, and neglecting the heat of oxidation of the small amount of electrode carbon consumed, we have:

Heat Available.

		Calories.
Supplied by electric current:		x
Oxidation of C to CO	191 × 2,430 =	464,130
Oxidation of CO to CO^2	271.1 × 2,430 =	658,770
Formation of silicate slag	106.8 × 150 =	16,020
Formation of CaS	9.4 × 2,947 =	27,700
Formation of Fe^3C	40. × 705 =	28,200
Sum	=	1,194,820 + x

Heat Distribution.

	Calories.
Reduction of Fe from FeO 703.2 × 1,746	= 1,229,790
Reduction of Fe from FeO 221.0 × 1,173	= 259,230
Reduction of Si from SiO 35.0 × 7,000	= 245,000
Reduction of P from P^2O^5 0.3 × 5,892	= 1,770
Reduction of Ca from CaO 11.8 × 3,288	= 38,800
Expulsion of CO^2 from ore 33.9 × 1,026	= 34,780
Evaporation of H^2O from charges 75.6 × 606.5	= 45,850
Sensible heat in gases, at 300	
CO 174.6 kg. = 138 m^3 × 0.311 = 42.9	
CO^2 459.9 kg. = 232 m^3 × 0.436 = 101.1	
H^2O 75.6 kg. = 93 m^3 × 0.385 = 35.8	
179.8 × 300	= 53,940
Sensible heat in slag 249.4 × 600	= 149,640
Sensible heat in pig iron 1,000 × 400	= 400,000
Loss by radiation, etc., 0.30 (1,194,820 + x)	= 358,450 + 0.3 x
Sum total	= 2,817,250 + 0.3 x

Equating the heat available and accounted for we have:

$$1{,}194{,}820 + x = 2{,}817{,}250 + 0.3\,x.$$

Whence x = 2,317,760 Calories

And the sum total of heat requirement is

3,512,580 Calories,

of which the electric current supplies

$$\frac{2{,}317{,}760}{3{,}512{,}580} = 0.66 = 66 \text{ per cent.} \qquad (3)$$

(4) A kilowatt-day of electricity is equal to

0.239 × 60 × 60 × 24 = 20,650 Calories.

There is, therefore, required per ton of pig iron produced:

$$\frac{2{,}317{,}760}{20{,}650} = 112 \text{ kilowatt days.} \qquad (4)$$

This figure might be materially reduced by using the waste gases to warm up the charges entering the furnace. It is also possible that in a properly designed shaft the gases passing out might contain nearly equal volumes of CO and CO^2, instead of 3CO to 2CO, as assumed in this problem, from best ordinary blast furnace practice. Any greater utilization of the heat-producing power of the carbon would decrease the electrical energy required; the above calculated value is given as a safe figure for this ore on which to base working calculations.

Problem 74.

At Sault Sainte Marie, Canada, roasted pyrrhotite ore was smelted with the addition of limestone and charcoal fines. The mixture used contained 400 pounds of ore, 110 pounds charcoal dust and 85 pounds limestone. The analyses of each of these materials was:

Roasted Ore.		*Limestone.*		*Charcoal Dust.*	
Fe^2O^3	65.43	CaO	52.00	Fixed C	55.90
CuO	0.51	MgO	2.10	Vol. matter	28.08
NiO	2.84	Fe^2O^3	0.60	Moisture	13.48
SiO^2	10.96	Al^2O^3	0.21	Ash	2.54
Al^2O^3	3.31	SiO^2	1.71		
CaO	3.92	P^2O^5	0.01		
MgO	3.53	SO^3	0.13		
SO^3	3.00	CO^2	43.15		
P^2O^5	0.03				
H^2O	5.57				

Using 165.65 kilowatts effective electric energy for 56 hours 20 minutes, there was produced 7,336 pounds of nickeliferous pig iron and 5,062 pounds of slag, having the following average compositions:

Pig Iron.		*Slag.*	
C	3.05	SiO^2	16.44
Si	5.24	Al^2O^3	13.86
S	0.01	CaO	42.87
P	0.05	MgO	8.80
Cu	0.81	CaS	13.34
Ni	3.94	FeO	0.84
Fe	86.90	Undetermined	3.85

Requirements:

(1) A balance sheet of materials entering and leaving the furnace.

(2) A heat balance sheet of the furnace, making necessary assumptions where data is not furnished.

(3) The thermal efficiency of the furnace.

Solution:

(1) The amount of ore used may be calculated either from the iron, the nickel or the copper. The nickel and copper are the easiest to use, because there is supposed to be none of them in the slag, but they are the least reliable, because present in such small amount. The pig-metal contains 7,336 × 0.81 = 59.4 pounds of copper, and since the roasted ore contains 0.51 × 63.6/79.6 = 0.41 per cent copper, the weight of ore used, on this basis, would be 59.4 ÷ 0.0041 = 14,493 pounds. As for nickel, the pig-metal contains 7,336 × 0.0394 = 289 pounds of nickel, and since the roasted ore contained 2.84 × 59/75 = 2.23 per cent, the weight of this used should have been 289 ÷ 0.0223 = 12,960 pounds. These figures differ so much that we will make the calculation on the basis of the iron. There is iron present as follows:

	Pounds.
In the pig iron 7,336 × 0.8690	= 6,375
In the slag 5,062 × 0.0084 × 56/72	= 33
Total in products	= 6,408

In 100 pounds of ore 65.43 × 0.7 = 45.80
In 21 pounds limestone 21. × 0.0060 × 0.7 = .08
In 27.5 pounds of charcoal 27.50 × 0.0025 × 0.7 = .04

In charge, per 100 pounds of ore used = 45.92

Therefore, ore necessary to supply the iron in products:

Pounds.

6,408 ÷ 0.459 = 13,961

with which will be used:

Charcoal = 13,961 · 110/400 = 3,839
Limestone = 13,961 × 85/400 = 2,967

We are now ready to construct the balance sheet as soon as we assume probable values for the composition of the volatile matter and ash of the charcoal. The ash might be taken as containing on an average: K^2O 15 per cent, CaO 40, MgO 20, MnO 15, and Fe^2O^3 10 per cent. The volatile matter is due to insufficient charring, and the gases given off on heating may be assumed as, by volume, CO^2 25 per cent, CO 15, H^2 50, CH^4 10. This would make the volatile matter to contain, in per cents by weight, carbon 33.7, oxygen 58.5, hydrogen 7.8 per cent. (The verification of this last statement is a nice little exercise in chemical arithmetic.) The full statement of the elementary composition of the charcoal, for use in making the balance sheet, is therefore:

	Per Cent.	
Fixed carbon	55.90	
Volatile carbon	9.46	28.08%
Volatile hydrogen	2.19	
Volatile oxygen	16.43	
Moisture	13.48	
K^2O	0.38	2.54%
CaO	1.02	
MgO	0.51	
MnO	0.38	
Fe^2O^3	0.25	

Balance Sheet, per 7,336 Lbs. Pig-metal.

Charges.		*Pig-metal.*		*Slag.*		*Gases.*	
Roasted Ore	13,961						
Fe^2O^3	9,135	Fe	6,375	FeO	25	O	2,735
NiO	397	Ni	289	NiO	28	O	80
CuO	71	Cu	59			O	12
SiO^2	1,530	Si	384	SiO^2	1,091	O	55
Al^2O^3	461			Al^2O^3	461		
CaO	547			CaO	166	O	109
MgO	493			MgO	493		
SO^3	545	S	1	CaS	490	O	327
P^2O^5	4	P	4			O	0
H^2O	778					H^2O	778
Limestone	2,967						
CaO	1,543			CaO	1,542	O	0
MgO	62			MgO	62		
Fe^2O^3	18			FeO	16	O	2
Al^2O^3	6			Al^2O^3	6		
SiO^2	51			SiO^2	51		
P^2O^5	0			P^2O^5			
SO^3	4			CaS	4		
CO^2	1,280					CO_2	1,280
Charcoal dust	3,839						
Fixed C	2,146	C	224			C	1,922
Vol. C	363					C	363
Vol. H	84					H	84
Vol. O	631					O	631
H^2O	518					H_2O	518
K^2O	15			K^2O	15		
CaO	30			CaO	30		
MgO	20			MgO	20		
MnO	15			MnO	15		
Fe^2O^3	10			FeO	9	O	1
Electrode	66						
C	66					C	66
	20,828		7,330		4,533		8,962

There is a lack of close correspondence between the weights and compositions of slag, as observed and as calculated, due evidently to inaccurate sampling and analyses of the roasted ore and slag.

(2) From the balance sheet we can deduce the heat evolved and absorbed in the chemical reactions in the furnace. The more involved items are calculated as follows:

Oxidation of carbon to CO: All the carbon put into the furnace as fixed carbon goes out as either CO or CO^2, except that going into the pig iron. The carbon burnt to CO in the furnace may be, therefore, taken as 1,922 + 66 = 1,988 pounds, evolving 1,988 × 2,430 = 4,830,800 pound-Calories.

Oxidation of CO to CO^2: There is given up in the furnace, by the reductions accomplished, 3,021 pounds of oxygen, of which 1,988 × 16/12 = 2,651 pounds would burn fixed carbon to CO, as above shown, leaving 370 pounds to burn CO to CO^2. This would oxidize 370 × 28/16 = 648 pounds of CO to CO^2, which would evolve 648 × 2,430 = 1,574,600 pound-Calories.

Heat energy of electric current: One kilowatt-second is 0.239 kilogram-Calories, or 0.527 pound Calories. The current being on 56 hours 20 minutes, or 202,800 seconds, the heat equivalent of the current used is:

0.527 × 202,800 × 165.65 = 17,704,000 pound-Calories

Heat in escaping gases: We are here confronted with the fact that no observation of the temperature of these was given. There is no essential reason why they should escape very hot from the furnace, if properly run and conducted, so we will assume a maximum temperature of 500° C. The gases would consist of 1,958 + 2,651 − 648 = 4,061 pounds of CO and 648 + 370 = 1,018 pounds of CO^2, from the oxidation of fixed carbon in the furnace; plus 1,280 of CO^2 from the limestone, and 666 pounds CO^2, 254 pounds CO, 97 pounds CH^4 and 60 pounds of H^2 from the volatile matter of the charcoal. To these must be added 1,290 pounds of water vapor. The heat is, therefore:

CO	4,315 lbs. =	54,800 ft³ × 0.304 =	16,650 oz. Cal.	
CO^2	2,964 lbs. =	23,950 ft³ × 0.480 =	11,500	"
CH^4	97 lbs. =	2,150 ft³ × 0.490 =	1,050	"
H^2	60 lbs. =	10,700 ft³ × 0.304 =	3,250	"
H^2O	1,290 lbs. =	25,500 ft³ × 0.415 =	10,550	"
	Sum =	117,100 ft³	43,000	" per 1°
			= 21,500,000	" per 500°
			= 1,343,750 lb.-Cal.	

The other items of the heat balance sheet are almost self-explanatory, and the complete balance is as follows:

Heat Available

	Pounds-Cal.
Energy of the electric current	= 17,704,000
Oxidation of C to CO	= 4,830,800
Oxidation of CO to CO^2	= 1,574,600
Combination of C with Fe² 224 · 705	= 157,900
Combination of Ca with S 220 × 2,947	= 648,300
Formation of silico-aluminate slag (SiO^2 + Al^2O^3) 1,600 × 150	= 241,400
Total	= 25,157,000

Heat Distribution

Reductions:

Fe^2O^3 to Fe	6,375 · 1,746	= 11,130,750
NiO to Ni	289 · 1,051	= 303,750
CuO to Cu	50 · 503	= 35,000
SiO^2 to Si	384 × 7,000	= 2,688,000
SO^3 to S	218 × 2,872	= 626,100
P^2O^5 to P	4 × 5,892	= 23,550
CaO to Ca	274 × 3,288	= 900,000
Fe^2O^3 to FeO	50 · 446	= 22,300
Expulsion of CO^2 from flux:		
	1,280 × 1,026	= 1,313,300

Evaporation of H^2O	1,290 × 606.5	=	783,400
Sensible heat in gases		=	1,343,750
Sensible heat in pig iron	7,336 × 400	=	2,934,400
Heat in slag	4,533 × 600	=	2,719,800
Loss by radiation, conduction, etc		=	332,000
		Total =	25,157,000 (2)

(3) The essential work done by the furnace is the reductions, evaporation of moisture and decomposition of carbonates. The heat in slag, iron, gases and radiation loss are all susceptible of diminution or of being more or less returnable to the furnace. The usefully applied heat is, therefore, 17,827,050 pound-Calories. To produce this there was consumed the 25,157,000 pound-Calories actually generated, and there was wasted 13,300,000 pound-Calories, the calorific power of the gases escaping from the furnace, which should have been generated or might be utilized, making a total of 38,527,000 pound-Calories disposable.

The working thermal efficiency over all was therefore:

$$\frac{17,827,050}{38,527,000} = 0.46 = 46 \text{ per cent.} \qquad (3)$$

Production of Steel.

There are three methods of producing steel electrically which are practicable. First, the electric furnace may replace the crucible simply as a melting apparatus, in producing a cast steel from cemented bars; second, the electric furnace may replace the crucible or open-hearth furnace as an apparatus in which to melt together wrought iron and pure cast iron, such as washed pig metal, although in this operation the electric furnace is more like the crucible method, in that there is not necessarily any oxidation of the metal or of its impurities in the operation; third, the electric furnace may be used to melt or keep melted cast iron, while its impurities are oxidized out by additions of iron ore, in this operation resembling the Uchatius method of making crucible steel or the "pig and ore" process of making steel in the open-hearth furnace.

The particular advantages possessed by the electric furnace processes are, compared with the crucible process, the larger quantities in which the steel can be made in one operation, the absence of carbon in the furnace lining, thus controlling better the carbon and silicon in the steel, and the higher temperature, enabling a more basic slag to be kept fluid and thus sulphur to be better eliminated; the advantages compared with the open-hearth furnace are the absence of gases of combustion in contact with the metal, and the higher temperature available, which permits of very basic, refractory slags being made and kept thinly fluid, and thus gives better control of sulphur and phosphorus. In addition to these, in both cases, may be mentioned the commercial advantages, for the saving in crucibles alone makes the electric furnace superior in this respect to the crucible process, and the electric furnace can compete successfully as regards cost with the regenerative open-hearth furnace wherever water power costs less than $10.00 per horse-power-year and coal costs over $5.00 per ton.

A particular point to be noted is, that when heating by combustion is used the efficiency of the absorption of heat by the charges decreases very rapidly as the temperature gets higher. For instance, if a cold ingot of iron is placed in a furnace the temperature of which is 1,500°, the iron absorbs heat with very great rapidity from the start up to, say, 1,000°, but with decreasing rapidity thereafter. The rate of transfer of heat from the gases to the iron is proportional to the difference of temperature, and is some fifteen times as fast when the iron is at 0° as when it is at 1,400°. If the efficiency of the heating by furnace gases is, say, 25 per cent in bringing metal up to 1,500°, it is likely that the distribution of this efficiency is distributed about as follows:

Heating from 0° to 500°	45 per cent efficiency
Heating from 500° to 1,000°	27 " "
Heating from 1,000° to 1,500°	3 " "

On the other hand, the conversion of electrical energy into heat in the substance of the material to be heated is not a contact or transfer phenomenon, but a thermodynamically frictionless transfer of 100 per cent efficiency, and equally so at the highest as at the lowest temperatures. Only radiation and conduction losses need be considered, the problem is not how much heat can you *get* into a body but how much can you *keep* in; it is already all in, 100 per cent of it, to start with. In a large, properly designed electric furnace the radiation and conduction losses of heat, even working to the highest temperatures, can be kept at 15 to 25 per cent of the total heat generated, giving an efficiency of 75 to 85 per cent.

It may very well be, that there are places where the relative prices of coal and electric power are such that coal is the cheaper for heating to 500°, at 45 per cent efficiency, or to 1,000° at 36 per cent efficiency, or even to 1,500°, at 25 per cent efficiency, but that the combination of heating by fuel to 1,000° at 36 per cent efficiency and then by electricity from 1,000° to 1,500°, at 70 per cent efficiency, would be the cheaper plan, or even by fuel to 500°, at 45 per cent efficiency, and then by electricity from 500° to 1,500°, at, say, 75 per cent efficiency, would be commercially advantageous.

Illustration: Steel bars are to be melted in an electrical furnace. It takes 300 Calories effective in the steel per kilogram to heat it to a tapping heat; the electric furnace supplies this at a net thermal efficiency of 75 per cent. To heat the bars to 750°, cherry red, without melting them, requires 88 Calories, or 29 per cent of the total. If the bars were heated in a coal furnace to 750°, and then transferred to the electric furnace, some 25 per cent of the electrical power might be saved. If this heating were done by coal having a calorific power of 8,500, at a thermal efficiency of 25 per cent, there would be needed 40 grams of coal. The question is, therefore, the relative cost of 88 ÷ 0.75 = 117 Calories delivered electrically and 40 grams of coal. The former requires 117 ÷ 0.239 = 490 kilowatt-seconds = 8.2 kilowatt-minutes = 0.14 kilowatt-hours. At $10.00 per kilowatt-year (8,760 hours) this would cost 0.14 × 0.114 = 0.016 cents. At $5.00 per metric ton the coal would cost 0.040 × 0.5 = 0.020 cent. Under such assumed conditions of cost of power and of coal the electrical heating, even up to 750°, would be the cheaper.

Problem 74

In an induction electric furnace of 170 kilowatts capacity, 4.7 tons of steel is made per day by melting together cold-washed pig iron and scrap iron, the melted steel carrying 350 Calories per kilogram.

Required:

(1) The electric energy in kilowatt hours required per ton of steel produced.

(2) The thermal efficiency of the furnace.

(3) If one-third the material used were put into the furnace melted, carrying 275 Calories per kilogram, what would be the production per day and the power required per ton of steel?

Solution:

(1) Energy for 4.7 tons		=	170 kw-days.
Energy for 1.0 ton		=	36.2 "
Energy for 1.0 ton		=	0.10 kw-year
Energy for 1.0 ton		=	869 kw-hours. (1)
(2) 1 kw-hour = 0.239 × 60 × 60		=	860 Calories.
869 kw-hours		=	747,340 "
Heat in 1 ton of steel = 350 × 1,000		=	350,000 "

$$\text{Thermal efficiency} = \frac{350,000}{747,340} = 0.47 = 47 \text{ per cent.}$$

(3) Heat in melted material used per kilogram of steel produced = 275 × 1/3 = 92 Calories.

Heat to be supplied by the current 350 — 92 = 258 Calories.

Production per day under these conditions:

$$4.7 \times \frac{350}{258} = 6.4 \text{ tons.} \quad (3)$$

Relative times for the heats = 1 to 0.74.

Energy required per ton = 170 ÷ 6.4 = 26.6 kw-days.
= 0.07 kw-year.
= 638 kw-hours. (3)

Problem 75.

An electric steel furnace running at full heat, and containing about 2,500 kg. of steel, loses by radiation, etc., 250,000 Calories per hour; 2,500 kg. of melted pig iron is run into the hot furnace, carrying 250 Calories per kilogram, and it is treated with 500 kg. of iron ore, previously heated to 500° C., and 50 kg. of limestone added cold. The steel produced carries 400 Calories per kilogram and the slag 600 Calories. The operation lasts 1 hour. Assume the following composition of materials used and made:

Pig Iron.	*Iron Ore.*	*Limestone.*	*Steel.*
Fe.....96.656	Fe_2O_3....85.93	CaO.....53.74	Fe.....99.60
C..... 2.700	FeO..... 3.96	MgO..... 0.17	C..... 0.11
Si..... 0.600	SiO_2..... 5.50	SiO_2..... 3.14	Si..... 0.11
Mn.... 0.025	MnO..... 0.63	Fe_2O_3.... 0.18	Mn..... 0.15
S..... 0.007	Al_2O_3.... 0.76	Al_2O_3.... 0.32	S..... 0.02
P..... 0.012	CaO..... 2.23	P_2O_5.... 0.006	P..... 0.01
	MgO..... 0.97	S..... 0.001	

The bath was treated by the final addition of 10 kg. of cold ferro-manganese, carrying 80 manganese, 16 iron and 4 carbon. The steel obtained weighed 2,630 kg.

Required:

(1) A balance sheet of materials entering and leaving the furnace.

(2) The weight and percentage composition of the slag.

(3) A balance sheet of the heat received and distributed.

(4) The net power required to run the furnace and the cost of power per ton of steel made, at $25.00 per kilowatt-year.

Balance Sheet.

Charges.		*Steel.*	*Slag.*		*Gases.*	
Pig iron.....(2500 Kg.)						
Fe.....	2416.4	2416.4	.....		.....	
C.....	67.5	2.5	.....		C.....	65.0
Si.....	15.0	2.9	SiO^2....	24.9	.....	
Mn.....	0.6	.....	MnO....	0.8	.....	
S.....	0.2	0.5	.....		.....	
P.....	0.3	0.3	.....		.....	
Ore.....(500 Kg.)						
Fe^2O^3.....	429.7	203.1	FeO.....125.6		O.....	87.2
FeO.....	19.8	.....	FeO.....	19.8	.....	
SiO^2.....	27.5	.....	SiO^2....	27.5	.....	
MnO.....	3.2	.....	MnO....	3.2	.....	
$AlO^{1.5}$.....	3.8	.....	Al^2O^3...	3.8	.....	
CaO.....	11.2	.....	CaO....	11.2	.....	
MgO.....	4.8	.....	MgO....	4.8	.....	
Limestone.....(50 Kg.)						
CaO.....	26.9	.....	CaO....	26.9	.....	
MgO.....	0.1	.....	MgO....	0.1	.....	
SiO^2.....	1.6	.....	SiO^2....	1.6	.....	
Fe^2O^3.....	0.1	.....	FeO.....	0.1	.....	
Al^2O^3.....	0.2	.....	Al^2O^3...	0.2	.....	
CO^2.....	21.2	.....	.....		CO_2....	21.2
Ferro-manganese (10 Kg.)						
Fe.....	1.6	1.6	.....		.....	
C.....	0.4	0.4	.....		.....	
Mn.....	8.0	3.9	MnO....	5.3	.....	
	3060.0	2631.6		255.8		173.4

(2) The slag contains:

			Per Cent.	
SiO^2	54.0	pounds	= 21.1	
Al^2O^3	4.0	"	= 1.5	
CaO	38.1	"	= 14.9	
MgO	4.9	"	= 1.9	
FeO	145.5	"	= 56.9	
MnO	9.3	"	= 3.6	
	255.8	"	= 99.9	(2)

Heat Available.

		Calories.
Electric current:		*x*
Oxidation of C to CO	65.0 × 2,430 =	157,950
Oxidation of CO to CO^2	0.9 × 2,430 =	2,190
Oxidation of Si to SiO^2	12.1 × 7,000 =	84,700
Oxidation of Mn to MnO	4.7 × 1,653 =	7,770
Formation of slag	22.6 × 150 =	3,390
Heat in melted pig iron	2,500 × 250 =	625,000
Heat in iron ore	500 × 77 =	38,500
Sum = *x* +		919,500

Heat Distribution.

		Calories.
Heat in melted steel	2,630 × 400 =	1,052,000
Heat in melted slag	256 × 600 =	153,600
Reduction of Fe^2O^3 to FeO	386.7 × 446 =	172,470
Reduction of FeO to Fe	203.1 × 1,173 =	238,240
Separation of carbon from iron	65 × 705 =	45,800
Heat in gas at 1,500°:		
CO = 151.7 kg. = 120.4 m^3 × 0.32 × 500	=	19,260
CO^2 = 1.4 kg. = 0.7 m^3 × 0.60 × 500	=	200
Loss by radiation, etc.	=	250,000
Total =		1,931,570

Heat to be supplied by current:

$x = 1{,}931{,}570 - 919{,}500 = 1{,}012{,}070$ Calories. (3)

(4) One kilowatt furnishes per hour 860 Calories, therefore, the power required to run the furnace is:

$1{,}012{,}070 \div 860 = 1{,}177$ kilowatts. (4)

At $25.00 per kilowatt-year a kilowatt-hour would cost

$\$25.00 \div 8{,}760 = 0.2854$ cents.

And the power to run the furnace 1 hour would cost

$0.002854 \times 1{,}177 = \$3.36$.

And the cost per ton of steel:

$\$3.36 \div 2.630 = \$1.32$. (4)

Problem 76.

It is desired to design a plant for the electro-deposition of pure iron by the Burgess process (see Transactions American Electrochemical Society, Vol. V., p. 201). The desiderata and data are as follows:

Output, 25 metric tons per day.

Current density, 110 amps. per square meter.

Anodes, 0.75 × 0.5 meters immersed × 3 m.m. thick.

Cathodes, 0.75 × 0.5 meters immersed × 1 m.m. thick at starting.

Cathodes to be run until deposit is 1.5 c.m. thick on each side.

Anodes run until 0.9 consumed.

Tanks, 1.00 meter deep, 0.6 m. wide, 2 m. long inside, filled to within 0.10 meter of top with electrolyte.

Working distance between anode and cathode 6 centimeters at starting.

Electrolyte contains 10 per cent $FeSO^4$, $7H^2O$, and 5 per cent $(NH^4)^2SO^4$, specific gravity 1.1, electrical resistivity 20 ohms per centimeter cube.

Voltage drop in connections and conducting rods 0.3 volt per tank.

Main conductors carry 2 amps. per m.m. square of section.

Net cost of electrical power, $25.00 per kilowatt-year

Requirements:

(1) The number of anodes and cathodes per tank and the number of tanks in the plant and their arrangement

(2) The weight of anodes and cathode sheets, increasing the weight of immersed part 10 per cent. Specific gravity of the rolled iron 7.9.

(3) The weight of ferrous sulphate and ammonium sulphate required to start the plant.

(4) The drop of potential across the electrodes at starting

and at the close of a deposition; the drop of potential per tank; the total voltage needed at starting the plant and when it is in regular operation.

(5) The cross sectional area of the main conductors.

(6) The time required to consume an anode plate, *i. e.*, in dissolving iron away equal to 0.9 of its weight.

(7) The time required to deposit a full cathode plate; specific gravity of the deposit 7.6.

(8) The electric power required to run the plant and its cost per ton of iron deposited.

Solution:

(1) 110 amps. per square meter deposits per day:

$$0.00001030 \times 110 \times \frac{56}{2} \times 60 \times 60 \times 24 = 2.757 \text{ grams Fe.}$$

Therefore, depositing surface required:

$$25,000 \div 2.757 = 9,140 \text{ square meters.}$$

Since one cathode plate has a depositing area on both sides of $0.75 \times 0.5 \times 2 = 0.75$ square meter, the number of cathode plates required in the whole plant is:

$$9,140 \div 0.75 = 12,187.$$

In one tank, if there are x cathodes and $x + 1$ anodes, the thickness of these plates at starting is, in millimeters, $x + 3 (x - 1) = 4x + 3$ m.m. The number of spaces between anodes and cathodes being $2x$, and each of these being 6 c.m. = 60 m.m. at starting, the spaces are $120x$ m.m. The length of the tank being, inside, 2,000 m.m.:

$$124x + 3 = 2,000$$

whence $x = 16.1$.

Each tank will therefore contain 16 cathodes and 17 anodes, at a distance apart, at starting of

$$\frac{2,000 - 16 - 3(17)}{2(16)} = 60.4 \text{ m.m.} = 6.04 \text{ c.m.} \quad (1)$$

Since we need 12,187 cathode plates we need

$$12,187 \div 16 = 761.7 \text{ tanks.}$$

Which means that we would use 762 tanks. (1)

The arrangement of the tanks in series and groups of series can be best discussed when we know the voltage drop per tank, grouping them so as to absorb either 110 or 220 volts per series in one group.

(2) An anode sheet weighs:

$$75 \times 50 \times 0.3 \times 7.9 \times 1.1 = 9,776 \text{ grams,}$$

of which there is immersed 8,888 grams.

The 17 anodes per tank weigh altogether:

$$9.776 \times 17 = 166.2 \text{ kg.,}$$

and the 16 cathodes, which are one-third as thick:

$$3.259 \times 16 = 52.1 \text{ kg.}$$

In the whole plant, at starting, the weights will be:

Anode sheets	$166.2 \times 762 =$	126,644 kg.
Cathode sheets	$52.1 \times 762 =$	39,700 " (2)

(3) Volume of liquid in tank:

$(1 - 0.1) \times 0.6 \times 2 =$ 1.08 cubic meters.

Weight of solution per tank:

$1.08 \times 1,000 \times 1.1 =$ 1,188 kg.

Weight of dissolved salts:

Copperas	= 118.8 "
Ammonium sulphate	= 59.4 "

Weight in the whole plant:

Copperas	= 90.5 tons.
Ammonium sulphate	= 45.3 " (3)

(4) At starting the surface of the electrodes are 6.04 c.m. apart, and 110 amps. passes through each square meter of electrode surface; therefore, $110 \times 0.375 = 41.25$ amps. pass from each free side of each anode plate to the corresponding side of a cathode plate. Neglecting the small cross sectional area of electrolyte outside the plates, the resistance of each space would be

$$\frac{20 \times 6.04}{75 \times 50} = 0.0322 \text{ ohms,}$$

and the drop of voltage across two electrodes:

$$0.0322 \times 41.25 = 1.33 \text{ volts.}$$

If we take into account the 5 c.m. free space at the sides of each electrode, and allow an equal amount as effective beneath, the cross-section of the electrolyte may be taken as

$$(75 + 5) \times (50 + 10) = 4,800 \text{ c.m}^2.,$$

and the resistance between two plates:

$$20 \times 6.04 \div 4,800 = 0.0252 \text{ ohms,}$$

and the drop $0.0252 \times 41.25 = 1.04$ volts.

This value is the more probable one of the two.

At the close of a deposition, neglecting the decreased thickness of the thin anode plates, the working distance is decreased by $1.5 \times 2 = 3$ centimeters, and the voltage drop between plates will then be:

$$\frac{20 \times 3.04}{4,800} \times 41.25 = 0.52 \text{ volt.}$$

In both cases the voltage drop in contacts and conductors being 0.3 volt, the working voltage per tank will be:

	Volts.
At starting	1.34
At end	0.82
Average	1.08

The voltage needed at the generators can only be calculated when we assume a plan of grouping the 762 tanks. If we assume 110 volts to be desired at the generators, we could run 102 tanks in one series, which would give 7½ series. If we used 220 volts at the generators 2 series of 190 cells and 2 of 191 would absorb at starting 255 and 256 volts respectively, but when in regular running, with tanks in all stages of deposition, 205 and 206 volts. This would be a reasonable and practicable arrangement. In reality, at least one if not two additional tanks would be slipped into each series, for at least that number would be out of circuit continuously, being cleaned and made ready for re-starting.

(5) The amperes per tank would be:

$$0.75 \times 0.5 \times 2 \times 16 \times 110 = 1,320.$$

And the area of the main conductors in each series:

$$1,320 \div 2 = 660 \text{ sq. m.m.} \quad (5)$$

(6) The part of the anode sheet immersed weighs 8,888 grams, of which 0.9 is 8.000 grams, and if the anode is an intermediate one it is corroded on both sides, and receives, therefore, 85 amps. of current. This current dissolves, per second:

$$0.00001036 \times 28 \times 85 = 0.024657 \text{ grams.}$$

And therefore the anode sheet will last

$$8,000 \times 0.024657 = 324,000 \text{ seconds.} = 90 \text{ hours.} \quad (6)$$

(7) The weight of deposit on both sides of a cathode plate is

$$75 \times 50 \times 2 \times 1.5 \times 7.6 = 85,500 \text{ grams.}$$

And the time required to deposit this, since it is deposited by 85 amps., is

$$85,500 \div 0.024657 = 3,467,600 \text{ seconds.} = 40 \text{ days } 3 \text{ hours.} \quad (8)$$

(8) Each series requires 1.320 amps. at 205 volts, or

$$1,320 \times 205 \div 1,000 = 270.6 \text{ kilowatts.}$$

The three series therefore require 812 kilowatts, which will cost

$$\$25.00 \times 812 \div 365.25 = \$55.68 \text{ per day.}$$

An average cost of power per ton of iron refined of

$$\$55.68 \div 25 = \$2.23. \quad (8)$$

The other items of cost in a well conducted refinery will about equal this sum, making the total cost of refining about $4.50 per ton of pure iron. With cheap soft steel used as the raw material, there is a striking possibility of such a process

being commercially practicable for furnishing one of the raw materials for producing the finest qualities of steel, the other raw material being washed pig metal of standard quality. We commend this possibility to the attention of the makers of fine steel.

The Aussig Glocken Process for Alkali Chloride Electrolysis.

By Dr. Otto Steiner.

Electrochemical methods are generally employed in chemical industries for the sake of simplifying the operation. Purely chemical processes, like the LeBlanc, Weldon, Deacon and Solvay processes, involve a whole series of different reactions in order to get the desired end products from common salt. The electric current, on the other hand, decomposes the salt in one single apparatus and in one single operation. The immediate products of electrolysis are chlorine gas at the anode and caustic soda at the cathode. It is only necessary to so construct the apparatus as to prevent the reunion of these two products.

For this purpose it is necessary to separate the anodic liquid, in which some chlorine gas is dissolved, from the cathode liquid which contains the caustic alkali. While the chlorine set free at the anode mostly escapes as gas, yet some of it dissolves in the liquid. If this anode liquid containing the chlorine then mixes with cathode liquid containing hydroxide hypochlorite will be formed.

By application of a diaphragm, it is possible to separate the anolyte from the catholyte so as to prevent the mechanical mixing of the two solutions, without preventing the passage of the electric current.

But the action between the two solutions is due not only to mechanical mixing, but is also electrochemical in nature, since the caustic alkali in the catholyte participates in the conduction of the current. The OH ions of the catholyte will travel through the diaphragm into the anolyte. In this way caustic alkali is transported towards the anode in spite of the diaphragm. In consequence of this, it is impossible on a large commercial scale to manufacture highly concentrated caustic solutions by the diaphragm process without running the risk of greatly reducing the ampere-hour efficiency, together with other troublesome disadvantages.[1]

Various methods have been suggested to prevent the electrochemical reaction between the two liquids. There are some hundred different processes, aiming at this end, but only those of special simplicity have proven industrially successful. This is especially the case for the Aussig "Glocken" (bell) process of the "Oesterreichische Verein für Chemische and Metallurgische Production in Aussig" (Bohemia). This process is now used on a very large scale (about 6,000 h.p.) in Austria as well as in Germany.

The general principle of the process is shown in Fig. 1. An earthenware bell (Glocke) is suspended in the salt solution in such a way that it does not reach down to the bottom. The anode is inside of the bell, the cathode outside.

The anode liquid, which has a green color on account of its content of dissolved chlorine gas, is of lower specific gravity and fills the upper part of the bell. The colorless cathode liquid fills the part underneath as well as the whole outside of the bell.

[1] The formation of hypochlorite by reaction of the anode liquid with the cathode liquid can be theoretically explained as follows: There is always hydrolysis in the anode liquid $Cl_2 + H_2O \rightleftarrows H \cdot Cl' + H \cdot ClO'$. The two acids react with the cathode liquid as follows: $K \cdot OH' + H \cdot OCl' + H \cdot Cl' = 2H_2O + K \cdot OCl' = K \cdot Cl'$. The KOCl and H_2O are very slightly dissociated, so that more hydrolysis will take place. Hypochlorite is again formed, and in that way the whole caustic alkali that enters into the anode liquid will be changed into hypochlorite.

Between both solutions is a layer of neutral solution, which remains at the same place, if the current, the content of hydroxide in the catholyte and the content of alkali chloride in the anolyte are kept constant. This can be accomplished in continuous operation by introducing the fresh salt solution into the bell above the anode, so as to distribute it very uniformly over the whole anode surface, and by continually removing the formed caustic solution from the cathode compartment by simply overflow.

The anolyte, containing chlorine, moves inside of the bell downwards in consequence of the continuous supply of fresh electrolyte. It finally passes outside of the bell, and the hydroxide of the catholyte will then react with the dissolved chlorine and form hypochlorite, which will be reduced to alkali chloride at the cathode. In practice this reaction between chlorine and hydroxide will cause a loss of 6 per cent in the ampere-hour efficiency.

The idea of permitting the anode liquid with the chlorine to pass over directly to the cathode is rather audacious and is almost stunning at first sight, because this is exactly the thing which ought to be prevented—namely, the mixing of the anolyte with the catholyte. But as a strong salt solution does not dissolve more chlorine than 0.4 per cent of its weight, the loss in ampere-hour efficiency is very small, it amounts on a large scale to only 6 per cent. On the other hand, this arrangement has other very great advantages. The liquid surrounding the anode is constantly maintained saturated with chloride and the OH ions, which migrate away from the cathode towards the anode, are thus prevented to reach the anode.

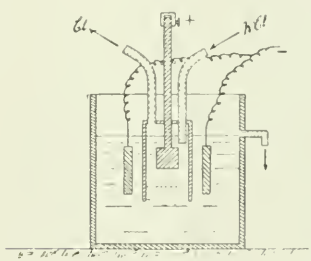


FIG. 1.—PRINCIPLE OF GLOCKEN PROCESS.

The reason is this: Both the OH ions and the Cl ions are migrating from the cathode to the anode, and the part which these two kinds of ions take in the electric conduction depends, according to Hittorf, on their number and their speed of migration. If, for example, the solution at the cathode contains 12 per cent KOH and 12 per cent KCl, it will be found that the negative ions traveling away from the cathode are almost completely OH ions.

But on their further advance towards the anode they will come into layers, which contain more KCl, and therefore more Cl ions, on account of the continuous supply of fresh salt solution at the anode. Therefore, the OH ions will gradually remain behind and the Cl ions will chiefly undertake the negative transmission of the current. At the anode itself the KCl concentration is maintained constantly at 20 per cent, so that the only negative ions moving at this place will be the Cl ions and no OH ions will reach the anode.

In expositions of the theory of the Glocken process the wrong idea is often found that the electrolyte moves inside of the bell downwards with the same speed with which the OH ions move upwards, and that it is necessary to regulate the rate of supply of fresh alkali chloride solution in such a way that the neutral layer which forms between the anolyte containing chlorine and the caustic catholyte remains on the same place.

Even the German patent 141,187 of the Aussig Co. uses this explanation. It is said there: "2. The continuous admission of fresh electrolyte at the anode is so regulated, that the speed with which the anode liquid passes downward, is equal to that with which the caustic alkali moves upwards on account of ionic migration, so that the separating layer between anolyte and catholyte is maintained constantly at the same place." It

would probably be more exact to say that the separating layer is maintained at the same place by keeping the alkali chloride concentration constant in the surroundings of the anode.

For, in reality, the explanation of the patent is not admissible. The position of the neutral layer depends chiefly on the concentration of caustic alkali at the cathode and on the KCl concentration at the anode and not on the speed with which the solution moves. The speed with which the electrolyte inside of the bell moves downward (in practice 1 c.m. per hour) is almost insignificant, since the OH ions travel with a speed of 6 c.m. per hour upwards

According to the patent these two speeds should be equal. But that is impossible in practice. To bring the downward speed of the solution up to 6 c.m. per hour it would either be necessary to accelerate the supply of fresh electrolyte so much that with a current density of 2 amperes per square decimeter of horizontal cross section of the bell (which is the limit on account of the disintegration of the anode material) a very weak caustic alkali solution would be obtained. Or it would be necessary to make the cross section of the bell below the anode so small that the voltage, and therefore the expenses for electric energy would be considerably increased. But all these things are unnecessary. If the liquid around the anode is continuously kept saturated with KCl or NaCl by careful subdivision and mixing of the fresh electrolyte, which is introduced into the bell, it is possible to prevent the OH ions from reaching the anode, provided there is no disturbing circulation of liquid within the bell.

For other reasons it would also be evidently impossible to regulate the admission of electrolyte so that the speed with which the anode liquid passes downwards is equal to that with which the OH ions move upwards. On that theory the neutral

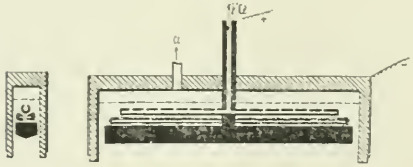


FIG. 2.—LATER CONSTRUCTION OF CELL.

separating layer would then only be stationary in the one case that both speeds are exactly equal. This can, of course, never be accomplished on a commercial scale, so that whenever the two speeds are not absolutely equal, the neutral layer would travel either upwards or downwards.

But, as a matter of fact, I have proved by experiments [2] that the neutral layer always remains at the same place, whatever the speed of the electrolyte may be, if only the current and the supply of fresh electrolyte are maintained constant. My explanation is therefore the only one admissible—namely, that the passage of the caustic alkali right to the anode is prevented in the Glocken process by keeping the liquid surrounding the anode as much as possible saturated with KCl, so that near the anode no OH ions participate in the negative transmission of the current.

The employment of a concentrated alkali chloride solution and a good distribution and mixing of the new with the old solution at the anode may also be used to advantage in the diaphragm and mercury processes where similar conditions exist.

The technical arrangement of the Aussig Glocken process requires a somewhat different construction, somewhat as shown in the adjoining Fig. 2. The even uniform distribution of the fresh solution over the whole anode surface and its thorough mixing with the solution, which already surrounds the anode, and which is weaker and therefore of lower specific gravity, are of greatest importance. In the patents of the Aussig firm it is specified, that for this purpose the anode should be made so large that it fills almost completely the whole horizontal cross-section of the cell. Only a small space of a few millimeter is left between the anode and the cell wall, and in this narrow space the rising chlorine bubbles cause an intimate mixing of the solutions.

I have proved experiments, that this condition alone is not sufficient, but that it is also necessary that the upper surface of the anode, or at least the exterior rim of it, should be absolutely level and horizontal. If this surface is only a little inclined, all the fresh solution, being of higher specific gravity, will flow down in one stream ("schliere") from the lowest point of the anode surface without being distributed over the whole anode surface and without getting thoroughly mixed with all the old solution. As a result the anode liquid will get weaker in alkali chloride. OH ions will come near to the anode, oxygen will be set free, disintegration of the anode material will occur, in short, we have all troubles which it is of greatest importance to avoid.

Not only the flat form but also the absolutely horizontal position of the anodes is therefore of greatest importance and every bell must be an apparatus of precision if it shall operate properly. By careful observation of this precaution Acheson graphite will prove such an excellent anode material that it will last for five years.

To sum up the advantages of the Aussig bell process, first of all we have the simplicity of its apparatus, then the high ampere-hour efficiency, the high concentration of the caustic alkali produced and the long life of the anodes. Its disadvantage is that for a large scale production a very great number of small apparatus are necessary, since the bells cannot be made too large. The diaphragm and mercury processes have also their advantages and disadvantages and it depends on local conditions which process one shall select. With respect to simplicity the Aussig Glocken process will not be excelled by any other electrolytic alkali-chloride process.

The "Oesterrenchischer Verein für Chemische und Metallurgische Production in Aussig" has not only invented the Glocken process but has also worked out all the details with so much success that the process is now used not only in Austria but in several places in Germany, in successful competition with the other older electrolytic processes.

The experiments on which the results given in this article are based were carried out under the direction of Prof. Dieffenbach at the Electrochemical Laboratory of the Institute of Technology of Darmstadt. The author wishes to express here his thanks to Prof. Dieffenbach for the assistance given him during the investigation.

CREFELD, Germany.

[2] Zeit. f. Elektrochemie, 1904, pp. 322 and 325; see also Electrochemical Industry, 1904, p. 245.

A 24-Ton Induction Furnace for Steel Manufacture.

The adjoining six illustrations show a 736-kw tilting Kjellin induction furnace for steel manufacture, which has just been completed at the Roechling iron and steel works in Voelklingen, Germany. This is the result of the success attained at the same works with two smaller induction furnaces. As was noticed in the paper of Mr. Hermann Roechling, on page 92 of our March issue, these two smaller furnaces have a capacity of 50 to 60 kg. (110 to 130 pounds) and of 300 kg. (660 pounds) respectively. The new furnace has a capacity of 24 tons of steel, 15 tons being poured at the end of a run, the balance remaining in the furnace for the next run.

The picture at the left in the first row shows the single-phase alternating-current generator which supplies the primary of the furnace with current. The picture at the right gives a view of the machine room. It illustrates the intimate relation which

exists between steel manufacture in the electric furnace and cheap power generation in gas engines.

The two pictures in the next row are two full views of the electric furnace, first in course of construction, then after completion. As already mentioned, the capacity is 24 tons of steel, 15 tons being poured at the end of a run. The electric power for operating the furnace is 736 kilowatts, or approximately 1,000 electric horse-power. Many of our readers have certainly seen small experimental induction furnaces in operation, but these illustrations afford a novel sight. One is impressed by them with the fact that those German steel masters do not intend to use the electric furnace as a play-thing or a show-thing, but that they mean business.

The two pictures in the last row give a rear view and a top view of the furnace. They show mechanical details with respect to the tilting arrangement, etc. The general features of the construction of the furnace are the same as shown in the diagrams on page 93 of our March issue. For the photographs from which these pictures are reproduced we are obliged to the American Grondal-Kjellin Co.

An interesting and quite novel feature of the same plant is a fourth induction furnace, now in course of construction. It has a capacity of 150 tons, but is not intended for steel making and refining proper, but will be used as a mixer and reservoir to keep the hot molten metal, which is tapped from the ordinary metallurgical furnaces and which is to be refined in the

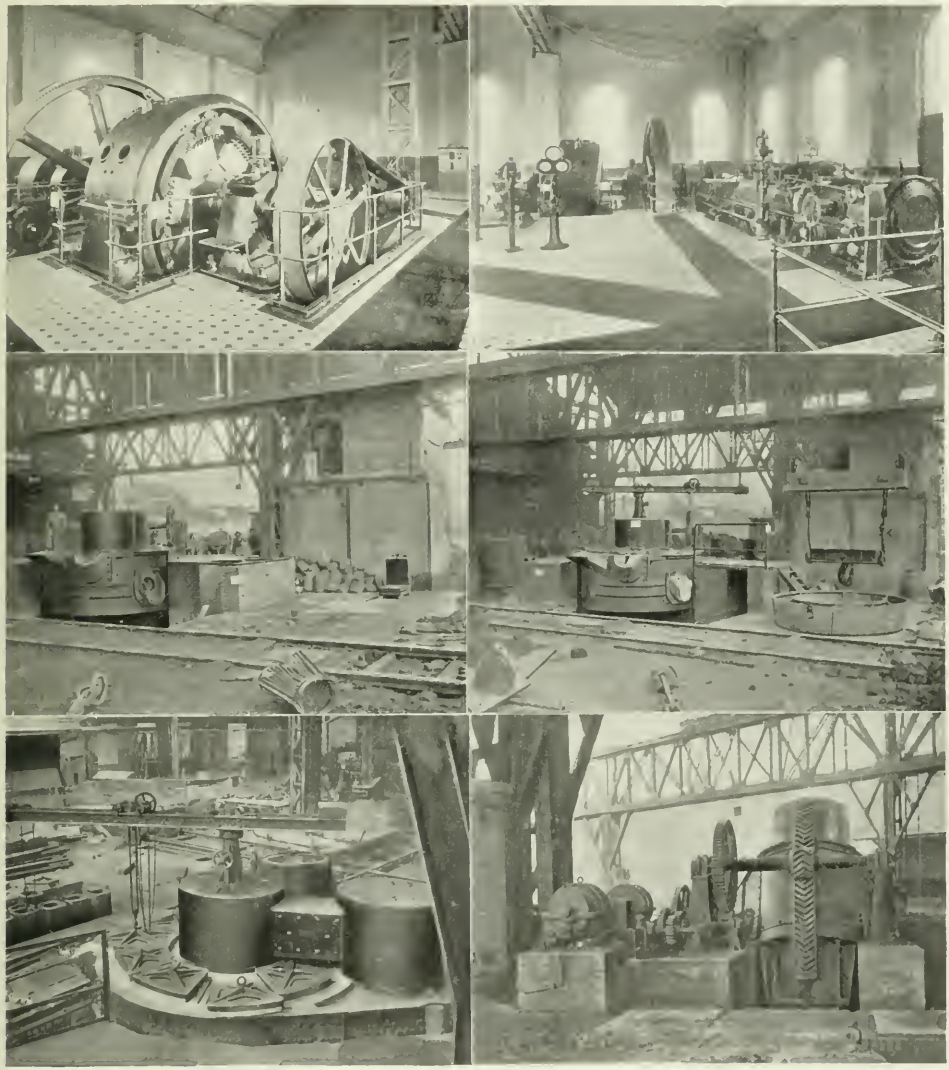


Fig. 1.—Alternator.
Fig. 2.—Generating Room.
Fig. 3.—Furnace During Erection.
Fig. 4.—Furnace After Completion.
Fig. 5.—Top View of Furnace.
Fig. 6.—Rear View of Furnace.

ELECTRIC STEEL FURNACE PLANT AT VOELKLINGEN

electric furnace, in molten condition. From this reservoir molten metal is to be run into the electric furnace right after the completion of a run, so as to maintain as much as possible continuity of operation.

In this connection it is interesting to give a summary of electric induction furnaces installed for commercial operation. In this country we have a Colby induction furnace at the Disston Steel Works in Philadelphia. In Europe the following Kjellin induction furnaces have been installed:

Gysingen, Sweden: 150 kw., 955 kg. (20,000 pounds). This is the original Kjellin furnace, reported on by the Canadian Commission (see our Vol I., p. 576, Vol. II, p. 479).

Gurtnellen, Switzerland: International Calcium Co.: 320 kw.

Voelklingen, Germany: Roechling Works. Of the following four furnaces the first three are in operation, the fourth in course of construction: First, 50 to 75 kw., capacity 50 to 60 kg. (110 to 130 pounds); second, 110 to 120 kw., capacity 300 kg. (660 pounds); third, 730 kw., pour 15 tons (15,000 kg. or 33,000 pounds); fourth, a 150-ton mixer to keep the metal molten.

Essen, Germany: Krupp Works, 746 kw.

Sheffield, England: Vickers, Sons & Maxim, 200 kg.

Araga, Spain: 200 kw.

There are further in course of construction a 300 to 400-kw. furnace at Guldsmedshyttan, Sweden, and another furnace of the same capacity at Poldihütte.

From the above figures for the furnaces at Gysingen and Voelklingen the following interesting figures on the relation between capacity of furnace and required electric capacity are derived:

Capacity in kg. steel	50 to 60	300		955	15,000
Electric power in kw.....	50 to 73	110 to 120		150	736
Approximate ratio of kw. to kg.	1		1-3	1-6	1-20

These figures are very instructive in showing in a general way how the electric power required per unit of output decreases with increasing capacity of the furnace. The electric energy, however, is only a single item in the cost sheet, and we have repeatedly pointed out that this item is comparatively small in the special case of manufacturing tool steels to compete with crucible steels.

To properly estimate the great progress which has been made by increasing the size of the furnace, it must be taken into account that other and really more significant items in the cost sheet are also substantially reduced, such as cost of labor per unit of output.

The chief point which we wish to make in this article is that large-size electric steel furnaces which enable a high economy of operation, are no longer only a possibility, but an established commercial fact.

Soap.

The New York Section of the Society of Chemical Industry held a meeting on April 10, the program for the evening being a symposium on soap. The following papers were on the program:

J. Lewkowitsch—Modern Views on the Construction of Soap.

W. C. Alpers—History and Uses of Soap in Pharmacy and Medicine.

Frank L. Rändel—Raw Materials for Soap Making.

D. Wesson—Cotton Seed Soap Stock.

Martin H. Ittner—Laundry and Toilet Soaps.

J. Merritt Matthews—Textile Soaps.

J. F. Hinckley—The Recovery of Glycerine from Soap Lyes.

William Dreyfus—Liquid Soaps from a Sanitary Standpoint.

A. C. Langmuir—Analysis and Valuation of CrudeGlycerine.

N. J. Lane—Determination of Castor Oil in Mixtures, Soaps and Alizarine Assistants.

The Use of Graphic Formulae in Metallurgical Calculations.*

By David H. Browne.

The daily records of furnace practice, the charge sheets, analyses, blast records, etc., are of value only in so far as they leave a permanent record in the minds of the furnace superintendent and his foremen, which record is termed "experience." As all these data, daily accumulating, become in time too numerous for the mind to carry, it is necessary to reduce them to terms of some common denominator and to group them in ways that will make them understood. In furnace practice also certain calculations are daily necessary, and these may be reduced to simple tables or charts.

The purpose of the present paper is to outline methods whereby the records of one particular ore may be tabulated and reduced to graphic formulæ. If a standard method, applicable to all ores, could be devised, then the science of metallurgy would approach the status of an exact science.

Suppose, for illustration, we have a large ore body consisting of chalcopyrite, pyrrhotite and diorite, and suppose that we have found by experience that the ore is regular in composition,

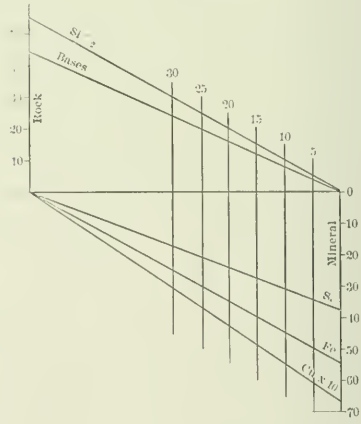


Fig. 1.—Diagram for finding percentage composition.

varying only in the relative proportions of minerals and rock. A fair average analysis is, we will assume, as follows: 4.50 Cu, 40.06 Fe, 25.66 S, 18.20 SiO_2, 6.30 Al_2O_3, 3.00 CaO, 1.20 MgO.

We have first to reduce this to its mechanical composition, considering it as a mixture of chalcopyrite, pyrrhotite and rock. Starting with chalcopyrite we have the analysis and ratio of this mineral to guide us.

Chalcopyrite: Cu 34.5 per cent = 1,000 parts; S 35 per cent = 1,014 parts; Fe 30.5 per cent = 883 parts.

The ore has 4.5 per cent copper, therefore, to form chalcopyrite this copper must be combined with iron and sulphur in the following amounts: S = 4.5 × 1.014 = 4.56 part S and Fe = 4.5 × .883 = 3.97 parts Fe.

We have in the ore as chalcopyrite: Cu = 4.5 per cent, S = 4.56 per cent, and Fe = 3.97 per cent; total 13.03 per cent chalcopyrite.

Deducting this sulphur and iron from the amounts in the original analysis we have: S = 25.66—4.56 = 21.1 sulphur left, and Fe = 40.06—3.97 = 36.09 iron left.

Taking this 21.1 parts of sulphur left, we combine it with

* A paper presented at the Toronto meeting of the Canadian Mining Institute.

enough iron to form pyrrhotite, of which the analysis and ratio is: Fe 61 per cent = 1,564 parts, and S 39 per cent = 1,000 parts.

The iron combined with the remaining sulphur is: Fe = 21.1 × 1.564 = 33.0 per cent Fe as pyrrhotite. We subtract this from the iron we had left after the chalcopyrite was satisfied: 36.09 — 33.00 = 3.09 iron left. This must be combined with oxygen, and as such will form almost 4 per cent iron oxide.

We can now reconstruct the mineral portion of the ore as follows:

	Cu	Fe	S
Chalcopyrite	4.5	3.97	4.56
Pyrrhotite		33.0	21.1
	4.5	36.97	25.66

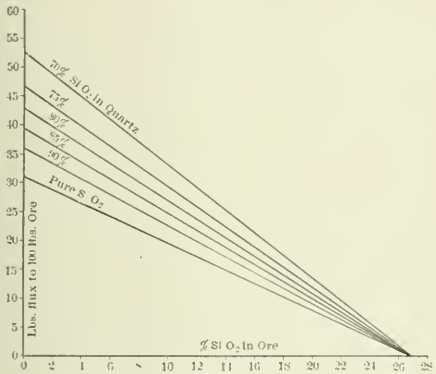


FIG. 2.—FLUX CHART.

Raising this from a total of 67.12 to 100 per cent we have 0.7 per cent Cu, 55.0 per cent Fe, 38.2 per cent S.

The rock materials which are left are:

		Per Cent
FeO	4.00	= 12.2
SiO_2	18.20	= 55.65
Al_2O_3	6.30	= 19.26
CaO	3.00	= 9.1
MgO	1.20	= 3.6
	32.70	99.8

For metallurgical purposes we can group these constituents as 55.65 per cent silica and 44.2 per cent bases.

We have now the mechanical composition of the ore as 67.12 parts mineral, containing 0.7 per cent Cu, 55.0 Fe and 38.2 S, and 32.70 parts rock, containing 55.65 per cent SiO_2 and 44.2 bases.

We can now assume that any ore from this mine will, in large quantities, correspond to some definite mixture of this mineral and this rock, and we can plot a chart showing what the composition of any such mixture will be.

Lay off on quadrille paper a base line containing 100 horizontal divisions. At the left-hand end erect a perpendicular, which we will call "rock." Lay off on this rock line the distances from the base line corresponding to the percentage of silica and bases in "rock," and connect these points with the zero at the right-hand end of the base line. From this zero at the right-hand end of the base line drop a vertical, which we will call "mineral," and on this lay off with the same scale distances corresponding to the Cu, Fe and S in the mineral. Connect these points with zero at the left-hand end of the base line.

We have now, Fig. 1, a vertical cross-section of which at any point will give the percentage composition at this point. For the sake of clearness we can lay out the copper contents on a scale ten times that of the other constituents.

Let us take silica as a standard, and lay off on Fig. 1 vertical lines corresponding to 5, 10, 15, 20, 25 and 30 per cent silica. We can now read off the ore composition for variations of 5 per cent silica.

For example: 20 per cent SiO_2 15.5 bases, 24.5 sulphur, 35.5 iron, 4.30 copper.

We can now draw up a slag chart covering the grades of ore we most commonly use. We take the pure mineral and calculate the proper slag for it; then we calculate the slag for an ore containing 20 per cent silica. By plotting these and continuing the lines we obtain a slag chart for ore of any composition between pure mineral and pure rock.

The pure mineral contains 0.7 per cent Cu, 55.0 Fe and 38.2 S.

This sulphur will be roasted to 12 or 13 per cent before coming to the smelter bins. This does not alter the slag calculation. We decide to make a matte carrying 40 per cent copper and a slag carrying 33 per cent silica. It is well known that copper mattes with 79 per cent copper contain no iron, and that 64 per cent iron mattes carry no copper. So by plotting copper on a vertical scale and iron on a horizontal, and connecting 79 per cent Cu with 64 per cent Fe, we get a diagonal line showing the amount of iron in mattes of any copper content. From this we find that a 40 per cent copper matte carries 32 per cent iron.

We make, for the present, no deductions for slag loss, but calculate as follows: 0.7 parts copper forming a matte containing 40 per cent Cu and 32 per cent Fe will take 5.36 parts Fe into the matte. The mineral has 55 parts iron, and after deducting the iron which goes into the matte we have 49.64 parts iron to go into slag. One part iron makes 1.28 parts iron oxide, so 49.64 parts iron make 63.59 parts iron oxide. We have, therefore, 63.59 pounds iron oxide from 100 pounds

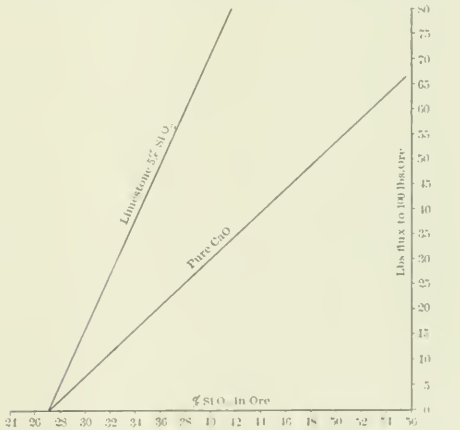


FIG. 3.—FLUX CHART FOR ORE WITH MORE THAN 27% SILICA.

mineral, and we have to add silica so that the silica is 33 per cent in the slag.

Let x = silica to be added, then $x = .33\ (63.59 + x)$, and x = 31.3 pounds silica. Therefore, 100 pounds pure mineral requires 31.3 pounds silica. Take now the ore mixture with 20 per cent silica, which we found to contain 20 per cent SiO_2 24.5 S, 35.5 Fe, 15.5 other bases and 4.3 copper.

This 4.3 parts Cu passing into matte requires 4.3 × 0.8 Fe* = 3.4 pounds Fe. Deducting this from 35.5 Fe we have left 32.1 pounds Fe to be slagged. Calculating this to iron oxide, 32.1 × 1.28 = 41.0 pounds iron oxide to be slagged. The total in

* Every 40 parts copper requires 32 parts iron to form matte, therefore 1 part copper requires 0.8 iron.

gredients passing into the slag are: 41.0 per cent iron oxide, 15.5 other bases, 20.0 silica (sum 76.5 per cent).

We have to add to this 20 pounds silica a certain amount x of outside silica, so that $20 + x$ will be 33 per cent of $76.5 + x$, hence $x = 8$ pounds silica.

We have thus found that a pure mineral requires 31.3 pounds silica and an ore with 20 per cent silica requires 8 pounds silica. We can plot these on a chart and read the amount of silica required for ore of any silica content. Such a chart is drawn in Fig. 2.

As we never have pure silica available for flux, we must lay off on the chart other lines corresponding to the amounts of quartz needed with varying silica content. Each 1 per cent of bases in the quartz abstracts 0.33 per cent of silica, so that a rock with 33 per cent silica would have no silica available. We can lay out a table showing the flux value of various grades of quartz:

Per Cent SiO_2 in Quartz	*Per Cent SiO_2 Available.*	*Lbs. Quartz to Equal 100 Lbs. Pure SiO_2.*
100	100	100
95	93.35	107
90	86.7	115
85	80.05	125
80	72.80	137
75	66.75	150
70	59.20	169
65	53.45	187
60	46.80	213

We can now plot on Fig. 2 the lines corresponding to the various percentage of silica in the quartz used for flux. The pure mineral takes 31.3 pounds of pure silica. If a quartz with 90 per cent silica is used, we have to take $31.3 \times 1.15 = 36$ pounds of this quartz. Making out a table of this we have: 100 pounds mineral requires 31.3 pounds silica; 36.0 pounds 90 per cent quartz; 39.1 pounds 85 per cent quartz; 42.8 pounds 80 per cent quartz; 46.9 pounds 75 per cent quartz; 52.8 pounds 70 per cent quartz.

A similar calculation can be made for ore containing 20 per cent silica: 100 pounds ore at 20 per cent silica requires 8 pounds silica; 9.2 pounds 90 per cent quartz; 10.0 pounds 85 per cent quartz; 10.9 pounds 80 per cent quartz; 12.0 pounds 75 per cent quartz; 13.5 pounds 70 per cent quartz.

Dotting in these points in their proper position and drawing the lines we complete Fig. 2.

We can now read off the amount of flux needed for any per cent silica in the ore mixture. For example: The ore is 13 per cent silica; the quartz the same day has 80 per cent silica. Finding 13 per cent silica on the base line we follow it up and find it intersects the 80 per cent silica line at 24 pounds. Therefore, 100 pounds of this ore will require 24 pounds of this quartz to make 40 per cent matte and 33 per cent slag.

These lines, it will be noted, all intersect at 27 per cent, showing that an ore with 27 per cent silica and with the other constituents as shown by Fig. 1, is self-fluxing for a 33 per cent silica slag. We may prolong this chart and see that ores with more than 27 per cent silica require the addition of a base, such as lime, or an iron ore, or a basic copper ore.

We will take limestone as an example, and assume we are using the same ore, making the same matte and slag, and using lime as the added base. Start the calculations with the pure rock which accompanies the mineral in our ore. This rock, by the calculation, contains 55.65 silica and 44.20 bases. We desire to make this into a slag with 33 per cent silica and 67 per cent bases. Evidently the amount x of added lime must be such that $44.2 + x = 67$ per cent of $100 + x$, hence $x = 66$ pounds CaO.

We can now make Fig. 3, laying off on the right-hand side a vertical on which we mark 66 pounds lime above the point showing 55.65 per cent pure silica. As 27 per cent silica ore is self-fluxing, we can draw a diagonal from this point to 66 pounds lime, and we have here a reading of the amount of lime needed for all ore between 27 per cent silica and pure rock.

But as on the silica side we have no pure silica available, so on the lime side we have to work with crude limestone, and we have to make a table showing the flux value of these limestones. A pure silicate of lime with 33 per cent silica carries 67 per cent lime, or simplified, 1 pound silica equals 2 pounds of lime. So in a limestone with 5 per cent silica, this 5 per cent silica neutralizes 10 per cent lime and cuts down the fluxing power of the limestone. We make a table of this:

% Silica in Limestone.	*% CaO in Limestone.*	*% Available CaO.*	*Lbs. Limestone to Equal 100 CaO.*
0	56	56	178
5	53.2	43.2	231
10	50.4	30.4	328
15	47.6	17.6	568

Suppose in the present instance our limestone has 5 per cent silica, and as we have shown 100 pounds pure rock needs 66 pounds pure lime, we multiply 66 by 2.31 and find that 152.4 pounds of this limestone are required.

We can now complete, Fig. 3, laying out the lines for pure lime and for any grade of limestone we have available.

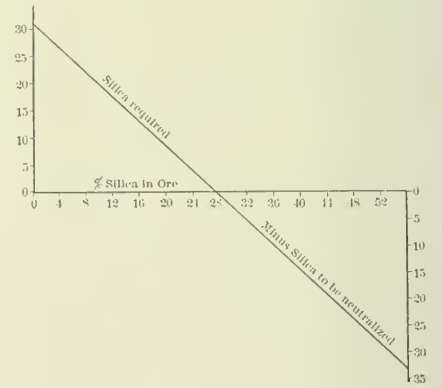


FIG. 4.—COMBINATION OF FIGS. 2 AND 3.

Suppose we have an ore with 38 per cent silica, Fig. 3 shows that 100 pounds such ore requires 60 pounds of our limestone. We can check this very readily. From Table 1 we find that this ore carries 38 per cent SiO_2, 18 iron, 30 other bases, 12 sulphur and 2.0 copper. This copper requires 1.35 pounds iron in matte, which leaves $18 - 1.35 = 16.65$ pounds iron to go into slag. Multiplying 16.56 by 1.28 gives 21.3 pounds iron oxide to be slagged. The slag constituents are 38 per cent silica, 21.3 iron oxide, 30.0 other bases (sum, 89.3 per cent). Or adding together all the bases we have 51.3 per cent total bases and 38.0 per cent silica (sum, 89.3 per cent). We desire to make slag with 33 per cent silica and 67 per cent bases. Therefore $51.3 + x$ CaO $= .67\ (89.3 + x)$ and $x = 25.8$.

Looking up Table 3, we find this checks out almost exactly. But our limestone has 5 per cent silica. Now, 5 per cent silica leaves 95 per cent $CaCO_3$, or $95 \times .56 = 53.20$ CaO in this limestone. As 1 pound silica in the slag neutralizes 2 pounds bases, so 5 pounds silica in the limestone neutralizes 10 pounds CaO—so we have $53.20 - 10 = 43.20$ available CaO. We have to use 25.8 pounds CaO, therefore, we use $25.8 \times \frac{100}{43.2} =$ 59.7 pounds of our limestone. Referring to Fig. 3 we find 60 pounds indicated, which proves the accuracy of our chart.

We could, however, have made this calculation in a much simpler way. From Fig. 2 we saw that the pure silica line ran

from 31.3 pounds required for pure mineral down to none for ore with 27 per cent silica. If we prolong this silica line diagonally to the right below our base, Fig. 4, we get a chart showing excess silica or negative silica, which if taken from the ore would make it self-fluxing. We have seen that in our slag, 1 part silica equals 2 parts lime, so if we read off our negative silica and multiply it by two, we get the amount of lime it requires. For example, on this chart an ore with 32 per cent silica has six points excess, or minus silica as shown by the lower silica line. Multiply by two gives 12 parts CaO to be added, which coincides with the amount of lime to be added, as shown by Fig. 3. Again, ore with 40 silica has fifteen points minus silica, which means 30 parts lime, which also checks out by Fig. 3.

We can in the same way plot mixtures of two or more ores in any fixed proportion. If the regular furnace charge be a mixture of two ores, the resultant mixture may be charted and a third ore figured as a flux. For example, if we have a mine A yielding silicious ore No. 1, and a mine B yielding an irony ore No. 2, we may decide on a standard mixture of, say, 1,000 pounds No. 1 to 2,000 pounds No. 2. This mixture can be charted and taken as a standard on which we may calculate the required amount of a limey ore No. 3.

Another interesting use of the graphic method is shown in Fig. 5. Suppose the standard furnace charge is 12,000 pounds of roast ore, and that this roast ore varies between 10 and 15 per cent sulphur; and suppose, further, that it is desirable to keep the sulphur contents constant at 13 per cent, and that we have a green ore containing 30 per cent sulphur with which to raise the amount of sulphur in the charge. We can lay out a chart showing just how much green ore must be added to roast ore of any sulphur content in order to raise the sulphur to any given percentage.

We start the calculation with some standard weights, for

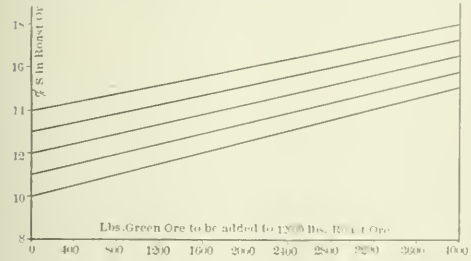


FIG. 5.—CHART FOR FURNACE CHARGE.

example: 12,000 pounds roast ore and 4,000 pounds green ore, as follows:

12,000 pounds roast ore at 10% S	= 1,200 pounds S
4,000 pounds green ore at 30% S	= 1,200 pounds S
16,000	2,400 = 15% S
12,000 pounds roast ore at 11% S	= 1,320 pounds S
4,000 pounds green ore at 30% S	= 1,200 pounds S
16,000	2,520 = 15.7% S
12,000 pounds roast ore at 12% S	= 1,440 pounds S
4,000 pounds green ore at 30% S	= 1,200 pounds S
16,000	2,640 = 16.5% S
12,000 pounds roast ore at 13% S	= 1,560 pounds S
4,000 pounds green ore at 30% S	= 1,200 pounds S
16,000	2,760 = 17.27% S
12,000 pounds roast ore at 14% S	= 1,680 pounds S
4,000 pounds green ore at 30% S	= 1,200 pounds S
16,000	2,880 = 17.9% S

Lay out on a vertical line at the left the different percentages of sulphur and along a horizontal line lay out the pounds of green ore from 0 to 4,000 pounds. Take the 10 per cent sulphur which we find was raised to 15 per cent by the addition of 4,000 pounds of green ore, mark the point corresponding to 15 per cent S above 4,000 pounds of green ore, connect this with the point corresponding to 10 per cent sulphur with no green ore. This gives a diagonal line along which we can read the sulphur obtained by mixing 12,000 pounds roast ore at 10 per cent sulphur with any amount of green ore at 30 per cent sulphur. Connecting the other calculated points we have Fig. 5 completed and can read from it any desired mixture of green and roast ore.

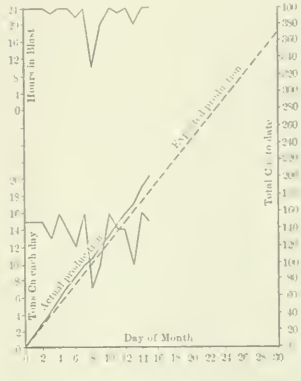


FIG. 6.—FURNACE CHART FOR A MONTH.

The method of charting the work of a furnace from day to day, so as to obtain a graphic record of its consumption and output, and also to obtain a prophetic estimate of its probable tonnage for the current month, is well known, but may bear repetition in this connection. Suppose a furnace smelting about 350 tons of ore and making about 12.3 tons of copper a day. If this furnace continues in blast every hour during the month we would expect 370 tons copper for this month. We lay off a horizontal line of thirty days, and on the thirtieth day erect a perpendicular upon which we mark a point corresponding to 370 tons, which we connect by a diagonal dotted line with the point on the base representing the beginning of the month. We graduate the right-hand vertical in a scale of tons from 0 to 370, and we graduate on the left a vertical column on a scale ten times as great for the daily output in tons. At the top of the left-hand column we lay off a scale of hours from 0 to 24, showing the number of hours the furnace was in blast each day. As we mark in each day's tonnage, we also mark in the total tonnage of copper produced up to date. This total tonnage to date, as long as the furnace produces 12.3 tons a day, will coincide with the dotted line of expected production but will deviate from this and fall either above or below it, according as the furnace produces more or less than the average amount of copper. Any delay or stoppage of the furnace is shown by the line representing hours in blast, and the cause of any delay may be marked by a circle enclosing a letter or figure referring to the usual causes of delay and explained in the legend. Such a chart from the 1st to the 15th of one month is shown in Fig. 6.

In the same way the output of the mines, the performance of day and night shift, the furnace records, tonnage of ores, flux, coke, analyses of the ore, amount or pressure of air may be tabulated from month to month. By plotting these on translucent paper, they may be laid one over the other for comparison, and in this way the resulting relations and points of economy may be discovered.

For example, the monthly averages showing copper in the matte and copper in the slag should be parallel if they are not a comparison of the slag with the quartz chart may show the cause of differences. Again, the matte grade and the life of the converter lining should be parallel, but a better grade of matte in a certain month is not accompanied by an increased duration of lining, the explanation may be found in the analysis chart of the quartz

used which may show bad quartz for the month in question.

Often, also, the continuous relation of two lines may open a field for study. For example, the silica in the ore and the percentage of sulphur in the ore after roasting may be inverse one to the other; which on investigation proves that a certain amount of rock helps the roasting by cracking and swelling and so opening up the ore in the roast beds. This shows, also, the desirability of keeping a certain amount of rock in the ore.

But the output of the furnace per month may also prove to be exactly inverse to the silica in the ore; and this raises the question of volume of slag loss and the metallurgical balance sheet. Frequently by such comparison we see that what is apparently the cheapest method is in reality the most expensive. It might be thought cheaper to leave silicious rock in the ore, than to pick the rock out and afterwards add barren quartz for flux;. but a comparison of the slag volumes will show that in many cases this apparent waste is an actual saving of expense.

There is no factor of furnace practice, except perhaps the personal equation, which cannot be studied by the graphic method. Even the personal equation may be referable to some disturbing condition. The number of furnace accidents may be shown to be greater under one foreman than another, or may reach a maximum at certain hours of the day, showing either individual carelessness or improper conditions under which the men are laboring. All knowledge comes by the intelligent comparison of data and the graphic method is the readiest means of making our data intelligible.

The Problems of Bleaching with Paper-Pulp Electrolytic Hypochlorite Solutions.

By W. Pollard Digby.

Among the problems announced as suggested for general discussion at the forthcoming Philadelphia meeting of the American Electrochemical Society, is one worded as follows: "Is the Electrolytic Preparation of Bleaching Solution for Pulp a Success?" This announcement led the present writer to compile and collate some notes from his memoranda on the subject, some of which were recent and some made about eight years ago.

At the outset the question arises as to how success is to be defined. Ultimately the answer will have to be expressed in terms of a monetary system of exchange. But before this ultra-commercial stage of regarding the question is reached, a number of dependent matters call for consideration. Until the advent of the McDonald electrolyzer, described in the February issue of Electrochemical and Metallurgical Industry, the problem was regarded as involving the choice of three alternatives, namely:

1. Calcium hypochlorite solutions prepared from chloride of lime.
2. Sodium hypochlorite solutions chemically prepared.
3. Sodium hypochlorite solutions electrolytically prepared.

The first of these undoubtedly holds the field. The second, which acts more rapidly, cannot hope to challenge its supremacy by reason of the waste of chlorine occurring during manufacture. In connection with the third, the writer is able to put forward in these columns some hitherto unpublished results.

Matters found to be of importance before any comparative data can be compiled are:

(a) Condition of pulp prior to bleaching. With wood pulps this is a constant factor for wood pulp from the same source; but where esparto grass is used its cleanliness is of great importance.

(b) Rapidity of action.

(c) Final color attained.

(d) Effect of bleaching medium on paper produced.

Clanliness of Pulp.

Taking these in the order given, the writer has found considerable differences between paper mill and paper mill using, say, esparto from Tripoli. Some mills, for instance, where washing water is plentiful, perform the operation of washing the boiled grass and breaking it up in special beaters. Other mills wash the boiled grass, and break it up in the same potcher in which bleaching takes place. The requirements of the latter class of mill in available chlorine are from 30 per cent and upwards in excess of some other mills of the former class. Moreover, the amount of washing accorded in mills of the latter class is not always a constant quality. It would, therefore, be well if some defined degree of cleanliness could be adopted as a standard. The writer would suggest the use of a quartz glass prism of wedge shape, the wedge tapering in depth from 3 inches to zero, and having a length of, say, 20 inches. Upon its stand would be secured a scale divided into fifth of an inch, the wedge having at its back a slab of porcelain of dead white color. The wedge would be fitted with a glass stopper and filled with an aniline dye of brown color, the solution being so prepared that the white slab observed through the thickest end of the wedge agreed with the color of a control plate of brown earthenware of the exact shade of unwashed esparto. A rectangular test tube would be filled with water squeezed from the pulp, and moved along the white slab above the wedge until the slab, regarded through the tube, agreed in color with the slab as seen through the wedge. The point on the scale corresponding to the middle point on the test tube would represent the degree of cleanliness attained.

No comparative tests of different bleaching media can be regarded as absolute unless the cleanliness of the washed esparto pulps is identical. An allowance of a definite number of gallons per cwt. of esparto as it comes from the boilers is not sufficiently exact, and the method pursued by the present writer of test tube comparisons might have been improved along the lines suggested.

Rapidity of Action.

The rapidity with which bleaching is effected depends, given pulp of a standard degree of cleanliness, upon the strength and quantity of the solution present, upon the nature of the base with which the available chlorine is allied, such as calcium, sodium or magnesium, upon any excess of such a basic hydrate, and upon the temperature during the process of bleaching. Chemically prepared sodium hypochlorite solutions of equal chlorine content are more rapid than calcium hypochlorite solutions, and electrolytically prepared sodium hypochlorite solutions still more rapid. This is probably due to their containing either no excess of alkali, or else such a small excess as is needed to ensure temporary stability. As regards temperature, the operation of bleaching is always expedited by heat, and temperatures within the potcher vary during hot bleaching from 90° to 110° F. Cold bleaching is resorted to frequently on Saturdays, when the bleached grass is likely to be left standing in the potchers over the week-end, when "hot" bleached solutions would have a tendency to revert to a yellowish shade.

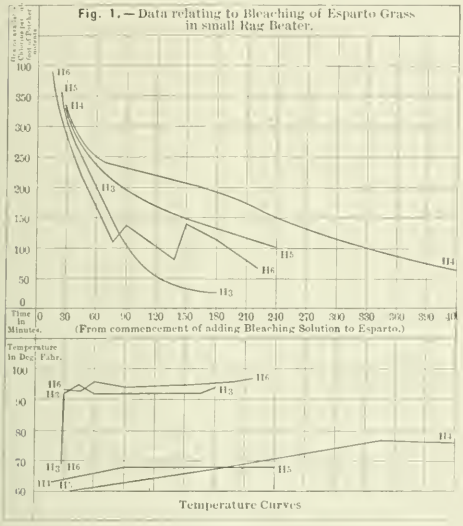
Final Color Attained.

When the bleaching operation is finished, that is to say, when a certain degree of whiteness has been attained and the available chlorine in the bleaching medium has been expended, the question arises as to how the whiteness secured should be described. From a number of reports I note such expressions as "good," "not quite up to mill standard," "white," "very good." All these expressions are somewhat relative, and the verbal expressions of the interested onlooker depend upon somewhat singular prejudices in regard to their outlook. Such visual basis is best met by taking a series of numbered pieces of glazed white china (differing in intensity) and recording those numbers which more nearly agree with the average product during any week, and the number of lots of each shade. If an agreed

standard of this nature is fixed in advancing, much subsequent argumentative debate, which hinges upon a biased eyesight on each side, may be obviated.

Collection of Data During Tests.

Having cleared up various preliminaries such as are outlined above, a series of tests may be commenced. Each test to be complete should describe (1) degree of cleanliness (if possible of the washed grass; if this is impossible the time allowed and amount of washing water in gallons should be stated); (2) the



quantity of esparto as obtained from the esparto boilers as wet esparto, together with the computed equivalent weight of dry grass;[1] (3) the quantity of bleaching agent supplied—as papermakers in England do not either use or think in metric equivalents, this may be expressed in gallons and the strength in grains of available chlorine per gallon of the liquor used; (4) the quantity of available chlorine present in the potcher upon the completion of adding the bleaching solution expressed in grains per cubic foot of potcher contents; (5) succeeding readings taken at stated intervals during the test, together with thermometric readings;[2] (6) final degree of whiteness attained.

If the above are noted, the quantity of available chlorine required per equivalent unit weight of dry grass will be established in an absolutely satisfactory and definite manner.

Figures of Actual Small Scale Tests in a Rag Beater.

Test No. H 3-5-4.—In this experiment 8 cwts. of wet esparto from the boilers (computed as equal to 4.16 cwts. dry grass) was bleached in a small rag beater. It was washed for 1 hour, but the quantity of washing water used was not recorded, the degree of cleanliness being checked by comparing the washing water at the end of this operation with a large potcher in the mill. The bleaching solution consisted of 140.9 gallons, containing 458.8 grains of available chlorine per gallon. Fig. 1 records the fall in chlorine strength during the test. Immediately upon the completion of adding the bleaching liquid, steam was turned on and the temperature readings were recorded. The extreme rapidity with which bleaching was effected was very surprising. The color is reported as good.

Test No. H 4-5-4 was carried out immediately after that recorded above. It was intended that this should have been a "cold" bleach, but owing to a leakage in the valve controlling the steam inlet the temperature gradually rose until a temperature of 77° F. was reached. The mean average temperature being about 70 F., this test cannot be regarded as an absolutely cold bleach. With an initial chlorine strength identical with that used in the preceding test, a slower fall is recorded with a slower rate of change of color. After 3¾ hours the color was noted as "almost white," there being present 120 grains of available chlorine per cubic foot of potcher contents. A further 2¼ hours only caused this quantity to fall to 75 grains per cubic foot when a perfectly satisfactory whiteness was attained. It is apparent, therefore, that a surplus had been used. Allowing that this margin amounted to 2,000 grains the total quantity used would amount to 67,500 grains.

It was, therefore, decided to use less quantities of chlorine in succeeding tests, and to use a greater quantity of esparto, drawing off as much water as possible before adding the bleaching solution, so that the quantity of chlorine per cubic foot of potcher contents would be greater.

Test No. H 5-15-4.—The solution used consisted of 122.37 gallons of 540.64 grains av. cl. per gallon strength. The quantity of wet grass being 10 cwts. 2 quarters, computed as equal to 4.16 cwts. of wet grass. This test being carried out on a Saturday, it was decided to treat it as a cold bleach. The extreme rapidity with which the whitening of the pulp was secured was strikingly marked. Initially there were about 350 grains of chlorine per cubic foot, and in 1½ hours, when the engine had stopped running, this had fallen to 135 grains. One and three-quarter hours afterwards there were still 100 grains of chlorine to the cubic foot, the color being fairly good. This continued to improve over Sunday, and on Monday the bleached pulp was worked up in the ordinary way.

Index Number of Test.	Actual Quantity Wet Esparto.	Computed Equivalent Dry Grass.	Electrolytic Hypochlorite Solution Used.		Time Required.				Total Grains Available Chlorine.		Grains Available Chlorine per Cubic Foot of Potcher Contents on Completion of Adding Electrolytic Solution.	Color of Product.
			Grains Av. Cl. per Gallon.	Total Grains Av. Cl.	From Commencement of Adding Solution.		From Completion of Adding Solution.		Per Cwt. Wet Esparto.	Per Cwt. Computed Equivalent Dry Grass.		
	Cwts.	Cwts.			Hrs.	Min.	Hrs.	Min.				
H3- 5-4....	8	4 16	458 8	147.	3	0	2	30	8,550	16,200	340	Good, but not up to mill standard.
H4- 5-4....	8	4 16	455.	153	6	30	6	0	8,680	16,800	340	Good, but not up to mill standard.
H5-15-4....	10.5	4.16	541.	122 4	3	55	3	30	6,300	15,900	360	Good, better than H3 or H4
H6-19-4.	11 0	5 20	612 595	104. 24	3	45	3	30	7,800	15,000	395	Very good

[1] The term "computed equivalent weight of dry grass" does not mean the actual dead weight of grass present on evaporation of the liquid contents, but the arithmetical equivalent proportion of grass as actually fed into the boiler, of which a certain proportion of the weight is lost in the liquor drained off, and returned to the soda recovery plant. W. P. D.

[2] Thermometers, being fragile instruments, are not supplied for the use of mill laborers. The human hand is somewhat delicate, but in practice I have not found it a successful device, the margin of error being about 5 F. W. P. D.

Test No. H 7-28-4.—The amount of esparto treated amounted to 11 cwts. of wet grass, a higher initial chlorine strength being required. The bleaching solution was added in one large and one small dose. The first dose consisted of 104 gallons of hypochlorite solution containing 612.50 grains av. Cl. per gallon. The initial strength within the potcher when this quantity was added amounted to 394 grains av. cl. per cubic foot of potcher contents. In 75 minutes from the completion of adding the solution the amount of chlorine had fallen to 105 grains per cubic foot. The addition of 15 gallons of hypochlorite solution at 595 grains av. cl. per gallon strength, caused a marked rise in the amount of chlorine present. A further addition of 9 gallons was provided 60 minutes later. The test was completed at 7 hours and 45 minutes, giving a good white color 45 minutes before completion. Although on the cure the addition of the two subsequent small doses causes an appreciable rise in the quantity of chlorine immediately present in the potcher, these rises are due to the fact that the bulk of the bleaching had been effected, and that the extra quantities merely gave an enhanced whiteness to the paper

Summarized Results and General Conclusions from Small Scale Tests.

From the figures given it is evident that the best results, as regards color and as regards quantity of chlorine required, were obtained when a solution of greater strength was used and when the fluidity of the material under treatment was reduced. This would tend to prove that if the washed grass had sufficient moisture extracted it would be possible to have an initially high chlorine strength within the potcher without an excessive amount dilution, or without the loss of electrical energy inseparable from the preparation of electrolytic solutions of high chlorine strength.

The small scale results being favorable, and the mill officials having pointed out that the use of the rag beater was in one respect unfavorable, namely, that the esparto was reduced to too fine a state of subdivision, and was therefore apt to be actually decomposed by the bleaching solution, it was decided to carry out five comparative tests in the large mill potchers. Three of these were made with electrolytic solutions and two with normal chloride of lime solutions.

Figures of Actual Large Scale Tests in Mill Potchers.

Whereas, the previous tests all took place in a small rag beater upon esparto only, the large scale tests were upon a mixture of esparto and wood pulp. The quantity of the wood pulp cannot be stated in these columns. It was, however, constant in each case, and is therefore noted in the test records as the standard proportion of wood pulp.

Test No. H 7-28-4.—The amount of esparto treated amounted to 20 cwts. of wet grass, and to this was added the mill proportion of wood pulp. Owing to the small size of the pipe between the electrolyzer and the potcher, some 2 hours and 55 minutes were occupied in adding the hypochlorite solution. A bleaching action was therefore taking place during this time, at the end of which there were 236 grains av. cl. present per cubic foot of potcher contents. The fall in the chlorine strength during the next hour and three-quarters is indicated in diagram No. 2. A good white color was obtained with the high quantity of 78 grains av. cl. per cubic foot of potcher contents unexpended. The total amount of hypochlorite solution used was 393 gallons, containing 600 grains av. cl. per gallon. This

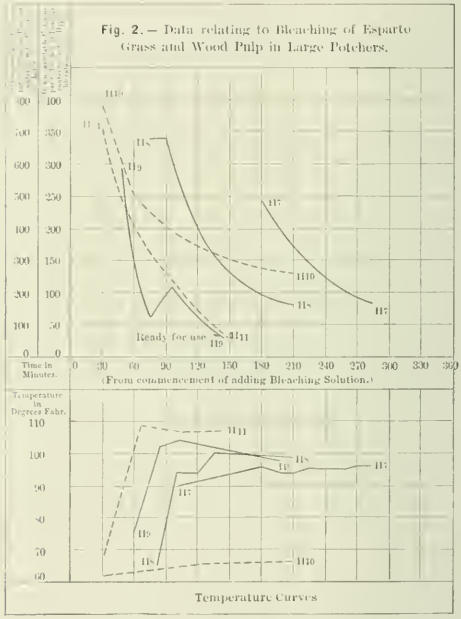


Fig. 2.—Data relating to Bleaching of Esparto Grass and Wood Pulp in Large Potchers.

quantity being in excess of the actual requirements, less quantities were subsequently used.

Test No. 8-4-5 was carried out upon an identical allowance of esparto and wood pulp. A less time was taken for adding the hypochlorite solution, only 70 minutes being so employed. The reason of curve 117 on the upper portion of diagram No. 2 remaining level for the first quarter of an hour, was due to the addition of a small quantity of solution (6 gallons during this time), after which the fall in chlorine strength took place at the usual rate. In 2¼ hours after the conclusion of adding the solution, the material in the potcher was bleached to a whiteness indistinguishable from that in the adjoining mill potchers using chloride of lime. An appreciable surplus of available

Series Number Test.	Actual Quantity Wet Esparto.	Computed Equivalent Dry Grass.	Electrolytic Hypochlorite Solution Used. Grains Av. Cl. per Gallon.	Total Grains Av. Cl.	Time Required. From Commencement of Adding Solution.		From Completion of Adding Solution.		Total Grains Available Chlorine. Per Cwt. Wet Esparto.	Per Cwt. Computed Equivalent Dry Grass.	Grains Available Chlorine per Cubic Foot of Potcher Contents on Completion of Adding Electrolytic Solution.	Color of Product.
	Cwts.	Cwts.			Hrs.	Min.	Hrs.	Min.				
H7–28–4.	20	8.65	600	393	4	40	1	45	11,780	27,200	240	Very good, better than H6.
H8–4–5.	20	8.65	471	421	3	25	2	15	9,920	23,000	340	Very good, indistinguishable from mill samples.
H9–11 5.	21	9.0	530	381	2	50	2	00	10,410	24,300	295	Very good, equal to H8.
			Chloride of Lime Solution.									
H10–M	20	8.65	1400	220	3	0	2	30	15,400	35,600	700	Very good.
H11 M	20	8.65	1400	220	3	45	3	15	15,400	35,600	800	Good, improved on standing over week-end.

chlorine has again to be noticed. The total quantity of solution used amounted to 421 gallons of 471 gr. av. cl. strength

Test No. H-11-5.—The total quantity of wet esparto, which came from Philadelphia instead of Tripoli, amounted to 21 cwt., and to this was added the standard amount of wood pulp. The bleaching solution was added in 50 minutes. During the next half hour an abrupt fall in the chlorine strength. This was so rapid that 31 gallons more solution was then added. In 2 hours from the start the material under treatment was of a very good color, and fit for running off for use. It was, however, kept in the potcher for another hour until a "chest" was ready, so that this batch could be made up separately. The total quantity of solution used amounted to 381 3 gallons of 530 grains av. cl. per gallon strength.

Test No. H-10-M.—For comparative purposes records were taken of the normal practice in the mill potchers using chloride of lime solution, and 20 cwts. of esparto plus the mill proportion of wood pulp. This was a hot test, the temperature rising to 107° F. Bleaching may be reckoned as beginning half an hour after commencing to add the solutions of chloride of lime, which amounted to 220 gallons, containing 1,400 gr. av. cl. per gallon.

Test No. H-11-M.—This was a "cold" test, taken with chloride of lime in the mill potchers, all quantities being identical with those in Test No. H-10-M.

Summarized Results and General Conclusions from Large Scale Tests.

Examining, in the first instance, Tests Nos. H-7, H-8 and H-9, in which electrolytic solutions of sodium hypochlorite were used, it is noteworthy that the best result was obtained when the chlorine contents of the potcher had the highest value immediately upon the completion of adding the bleaching fluid, and that this involved the smallest total consumption of chlorine per unit of dry esparto in the series. Further, this best result was attained with a solution of 471 grains per gallon strength, as against a solution of 600 grains per gallon strength in the test immediately preceding. It seems a reasonable inference, therefore, that an important factor is that of the amount of moisture present in the washed pulp before adding the bleaching liquid. This phenomenon is analogous to some which occur in the smelting of steel, the initial intensity of the chlorine present per unit volume of potcher contents, corresponding with the temperature attained in the metallurgical operation. Too low a temperature continued for a long time with a large thermal outlay would be practically without effect in the elimination of certain impurities, whereas a sufficiently high temperature for a shorter time, with a less thermal expenditure will secure the desired end. In bleaching too low a chlorine strength, even if maintained for a longer time, involving a larger consumption of available chlorine fails to give the same grade of whiteness that can be secured where there is less initial moisture present with the fiber and the initial chlorine strength greater.

Quite apart, therefore, from questions of the cost of the solution and methods of production it is evident that the grass to be bleached should be as dry as possible, and this can be secured by squeezing the washed grass in a press

Passing next to comparisons between the electrolytic solution of sodium hypochlorite and chloride of lime, the most striking feature is that the bleaching action of 1 gram of chlorine in the former is equal in intensity to 1.52 grams of chlorine in the latter; that appreciably lower temperatures may be used, about 10° F. less for hot solutions; and that the action is much more rapid for cold solutions. The difference in efficacy of the chlorine atom in the electrolytically prepared sodium hypochlorite molecule, as compared with the chlorine atom, the chemically prepared calcium hypochlorite molecule can only be explained on the hypothesis that the former is less stable in the presence of organic matter, and acting with a greater rapidity involves less loss through actual disintegration and decomposition of the fiber than takes place with more stable substances.[1]

Having, however, determined for any paper mill the requirements in available chlorine for the mill potchers in regard to regular working conditions, the total requirements of the mill per day can be estimated. The question then passes from the hands of the chemist to those of the electrochemist and electrician.

The Cost of Producing Hypochlorite Solutions Electrolytically.

This may be summed up roughly as so many kilowatt-hours of electrical energy, and so many pounds of sodium chloride per unit quantity of available chlorine produced. A rough approximation will not, however, suffice. What may be termed as the efficiency characteristic of the electrolyzer should be determined in regard to the units of electricity and weight of sodium chloride required per kilogramme of available chlorine produced for solutions of different strengths. As is well known, the initial high electrochemical efficiency falls as the strength of the solution rises, while the salt consumption falls continuously. The resultant cheapest cost of production depends upon the respective local costs for energy and salt. The efficiency and salt consumption characteristics of most electrolyzers are recorded in Engelhardt's "Hypochlorite und Elec-

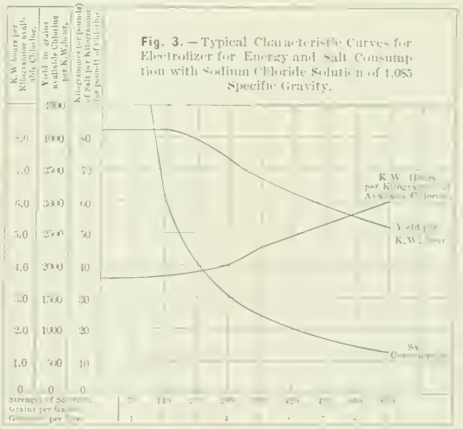


Fig. 3.—Typical Characteristic Curves for Electrolyzer for Energy and Salt Consumption with Sodium Chloride Solution of 1.085 Specific Gravity.

trische Bleiche," and in issues of the technical press appearing subsequently to the Engelhardt monograph. The writer presents in Fig. 3 the characteristic curves for the electrolyzer used by him in his experiments

The application of its results to any paper mill depends, as has been said, upon local circumstances. In Fig 4, hypothetical cost curves are reproduced for the electrolyzer upon a basis of electrical energy at 2 cents per kilowatt-hour, and for salt (i. e., sodium chloride) $4.00 per ton of 2,000 pounds. As will be seen, minimum cheapness of production is secured under these circumstances for solutions of 350 grains available chlorine per gallon strength. If the salt cost were unchanged, electrical energy could be secured at a cheaper rate, the cheapest working point being at higher strengths, and an increase in the cost of electrical energy would shift the cheapest working point towards lower strengths of solution

One important matter in the history of the production of electrolytic hypochlorites has been that the price of electrical energy has controlled its field with cheap power rates and the very good [illegible] factor which such processes offer, greater

[1] It would be interesting to ascertain whether in the case of the calcium hypochlorite solutions produced by the McDonald electrolyzer any difference exists either in regard to stability or in regard to requirements per unit quantity of chlorine produced, as compared with calcium hypochlorite solutions made in the ordinary way from chloride of lime. W. P. D.

attention has been of necessity diverted to reductions in the salt consumption. Primarily in electrolyzers of the Woolf, Hermite Crawford, Haas and Stahl, Vogelstein or Atkins types, this has been secured by methods of cooling, improved circulation and so forth, in order to secure liquids of a higher strength in available chlorine. A recent British patent (No. 21,049 of 1905) provides for the isolation of the respective anodic and cathodic products by means of diaphragms from the main body of the electrolyte, and their recombination in the electrode compartment, where one or other of these products is liberated in a nascent condition. Very great reductions in

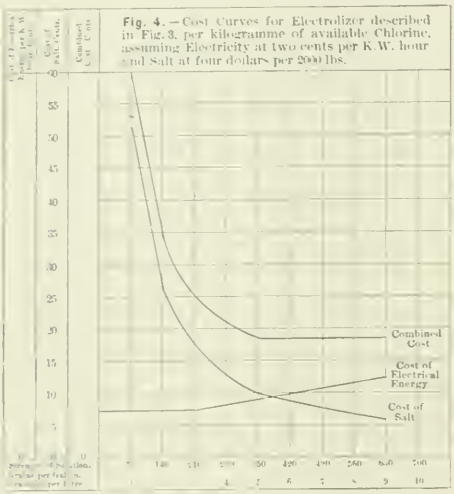


Fig. 4.—Cost Curves for Electrolizer described in Fig. 3, per kilogramme of available Chlorine, assuming Electricity at two cents per K.W. hour and Salt at four dollars per 2000 lbs.

the salt cost are effected thereby. In the McDonald electrolyzer, sodium hypochlorite is not produced in the main body of the electrolyte, but calcium hypochlorite is produced by the action of the chlorine gas upon a lime solution in chlorination towers.

For all electrolyzers in which the recombination of the anode and cathode products takes place in the main body of an electrolyte rich in salt, further salt savings than have yet been secured are necessary if such electrolyzers are to compete on the most favorable terms with chloride of lime. This can only be done if the electrolyte, after performing its operation of bleaching in the potchers, is squeezed out of the pulp, and after sedimentation and filtration returned to the electrolyzers. For this to be done properly the grass should be squeezed in a press after washing, and the proper weight of dry, clean grass put in a potcher and bleached with the hypochlorite solution. After bleaching it would have to be squeezed in another press. The salt loss by this process becomes merely a matter of the residual sodium chloride remaining in the interstices of the fibers of the pulp, and a recovery of from 70 to 80 per cent of salt becomes easily feasible.

A saving of this kind acts in two ways. In the first place, the salt consumption is reduced to three-tenths, or even two-fifths of that shown on the electrolyzer characteristic curve, and therefore obviously modifies the salt cost curve; and in the second place, modifies the combined cost curve in a manner permitting of working at lower chlorine strengths and with higher electrochemical efficiencies.

The Comparative Balance Sheets.

At this stage, when the cost curves of the electrolyzer are prepared from the efficiency characteristic curve and salt consumption of curve, upon local prices and conditions as to salt recovery, it becomes possible to discuss alternative balance sheets and their composition. On the one hand, the mill consumption of chloride of lime per potcher, or per working week is known, and its cost free on rails at the mills obtained. To this cost must be added that of the labor required in handling the chloride of lime and mixing and pumping the solution, together with the cost of returning the empty casks and disposing of the insoluble lime sludge. On the other hand, the consumption of electrolytic hypochlorite having been ascertained, and its cost for electrical energy and salt known, there must be added such items as interest on capital outlay, wear and tear on generating plant (if one has been installed), wear and tear of electrolyzers, together with the energy consumption required by such auxiliary machinery as may be used for mixing the saline solution, cooling the electrolyte, filtering the returned saline liquor from the potchers, as well as the cost of operating the presses which squeeze the moisture from the pulp, together with the labor required.

General Conclusions.

The investigations which the present writer has conducted, both in the laboratory and in large scale experiments, lead him to believe very strongly in the possibilities of electrolytic hypochlorite processes for paper and textile bleaching. It is necessary for effective bleaching that the initial strength of available chlorine within the potcher should not be less than 350 grains per cubic foot, and it does not at present seem necessary that this value should exceed 500 grains. The intensity of the whiteness attained depends largely upon this initial strength and upon the material not being too fluid in its nature. With pulp free from too much moisture, solutions containing from 3.0 to 4.0 grammes of available chlorine per liter can be produced at a high electrochemical efficiency. The electrolytic solutions act with greater rapidity, and the degree of heating need not be pushed so far. Above all, there remains the fact that one atom of chlorine in the sodium hypochlorite molecule in the electrolytic solution is more potent than one atom of chlorine in the calcium hypochlorite molecule of a chloride of lime solution. In the case to which the present figures refer this margin was found to be 1.5 to 1.0. In the case of another mill, the writer estimated it at 1.65 to 1.0, and a consulting chemist, to whom the mill owners referred the question, reported from his laboratory tests that the figure was nearly 2.0 to 1.0.

Finally, the writer would strongly deprecate the application of these figures which are true of one mill, or of any other figures equally true of another mill, to any and every case which may transpire. Each case requires detailed local examination before any declarations are made.

Pierre Eugene Marcelin Berthelot[1].

By Charles A. Doremus.

France, for the third time in the space of a few months, mourns the loss of an illustrious savant. Again the nations of the world extend their sympathy. The heroes acclaimed were not martial victors over mankind, whose honors were bought in the price of blood, but men of lofty ideals who conquered nature, brought truth to light, instituted new industries and improved old ones, thus bettering man's physical, and through enlightened thought elevating his moral condition. Truly "science guides humanity."

Curie, Moissan, Berthelot! How varied the achievements of each, though each chose chemistry as a field of labor. How differently each worked out his task and how successfully.

Berthelot was born in Paris, Oct. 25, 1827. His father was a physician, and the young man inherited not only a taste for

[1] Read at the meeting of the New York Section of the American Chemical Society, April 5, 1907.

a scientific career, but was schooled most effectually for it. His education at the Lycée Henri IV. developed the taste for historical research which won him his first prize and which later directed his attention to the early history of alchemy, the foundations of our science. His great erudition, his mastery of the Greek language and his love of exactitude in securing fundamental facts have given us nine volumes covering the several topics of these researches. They appeared from 1885-1893 and represent his maturer years when the activities and acquisitions of middle life were subjected to the criticism of a calm judgment. This phase of Berthelot's character is also seen in his frequent minor articles dealing with questions of education, morals and philosophy. He possessed a marvelous memory. He lived in a period when the sciences were rapidly developed. He obtained an extraordinary grasp of their relationship. He lived in an environment which was stimulating. He quickly understood what was fundamental in each, and so at eighty he was one of that type of men, now growing rare because of the intense specialization of our day, known as "the encyclopedists."

His first scientific memoir was presented to the Académie des Sciences May 27, 1850. It described the liquefaction of gases by the pressure secured by the dilatation of mercury. He found that pressure alone would not reduce gases to the liquid state. From that date there was no cessation in his labors; he attended, as its perpetual secretary, a meeting of the Académie within an hour of his death, March 18, 1907.

He became assistant to Balard at the College de France and obtained his doctorate in 1854, with a sensational thesis on the synthesis of natural fats from glycerin and the fatty acids. A continuation of these researches, especially on the polyatomic alcohols led, in 1863, to the founding of the chair organic chemistry at the Collége de France, that he might have the conditions for carrying out his personal ideas. He thus entered on a field of work which made him famous. *Analysis* had until this period been the chemist's aim. *Synthesis* now claimed his attention, and before the end of the nineteenth century wonders were indeed wrought, revolutionizing both philosophy and the arts.

Prof. and Mme. Berthelot.

By causing an electric arc to play between carbon electrodes in an atmosphere of hydrogen Berthelot secured the direct union of carbon and hydrogen with the production of acetylene. He then converted this by the action of heat into benzene, and from these passed to other syntheses. He also experimented with the silent discharge turning oxygen to ozone. With the induction current he combined acetylene and nitrogen to hydrocyanic acid. He obtained formic acid starting from carbon monoxide. By the use of sealed tubes in which chemicals were subjected to high temperature and pressure through considerable time he influenced them to combine, and also gave us a new general method in chemical manipulation. Six important works, in all nine volumes, attest his genius as applied to this department of his labors. His soul was in his work. When one contemplates how his experiments steadily progressed, effecting the grouping of the elements to form hydrocarbons, alcohols, acids, ethers, sugars, fats, thus simulating natural processes and building up compounds which up to his day were conceived as being solely the result of vital force, we little wonder that he became permeated with the idea that ultimately man would manufacture his own sustenance. In his address to the second International Congress of Applied Chemistry he says: "No one can deny that the day is perhaps near when the progress of chemistry will realize the manufacture of foods; in that day the cultivation of wheat and the raising of cattle will be exposed to the same destiny which has overtaken the culture of madder in our day." What perplexing situations will then arise with reference to the pure food law!

Berthelot took an active part in the great movement of the middle of the nineteenth century when the correlation of the sciences was discussed and the conservation of energy was established as the basic principle in physics. It was, therefore, natural that he should attempt to measure the energy developed by chemical reactions in definite terms. He labored indefatigably for thirty-five years in founding thermochemistry. The facts and principles are collected in two volumes published in 1897. They had been preceded by a work entitled "Essai de Méchanique Chimique," also in two volumes, 1879, followed by a volume, "Traité pratique de Calorimétrie Chimique," 1893. His two volumes "Sur la force des matières explosives," 1883, was intimately connected with these other laborious researches in thermochemistry, and led to the discovery by others of smokeless powder. His work on the detonation of endothermic substances, such as cyanogen and acetylene, was followed by a research on explosive waves by which he elucidated many seeming contradictory facts. During the stirring times of 1870 Berthelot was made president of the scientific committee on defense; he afterwards became consulting member of the committee on powder and saltpetre, and president of the commission on explosives. In connection with these duties he devised many original methods of research.

His thesis that chemical phenomena are identical in animate and inanimate nature is thus expounded in 1855: "We may, I say, claim to form anew all the substances which have been developed since the origin of things, to form them under like conditions in virtue of the same laws, by the same forces which nature brings into play in their formation."

And as a necessary sequel of his life's work we find him attacking the serious problems of the theory of agriculture and of biological chemistry. His "Chimie Agricole," in four volumes, and his "Chimie Animale," in two volumes, were both published in 1899.

The beautiful experiment farm at Meudon was the scene of his labors. One climbs the "tour Berthelot" of over eighty feet in height and about one is the charming scenery of this suburb overlooking Paris. Here the master undertook his experiments on the influence of electricity on the growth of plants—generating this force or deriving it from the atmosphere. Here it was that the fixation of nitrogen was studied, a problem that has engaged the sturdiest minds, and here it was that he found that microbic life was the means of transferring atmospheric nitrogen to the living plant cell. The import of this phenomenon he tersely stated in saying: "The soil is something alive!" To us the products of whose broad acres furnish enough for ourselves and to spare this discovery is of incalculable value. And yet this man, who instructs us in eco-

...me farming, he did not hesitate to indicate how we may manufacture our own food and thus make ourselves independent of climatic influences.

The experimental investigation on plant life led to that of the animal organism. The principles of the production of heat in living beings was a topic quite germane to the investigations on thermochemistry.

While Berthelot found his greatest pleasure in experimentation in science he was fully alert to the intimate relations his investigations bore to the advancement of the liberal arts. He made his position in this regard quite clear to the audience he addressed at the second International Congress of Applied Chemistry:

"In chemistry, as in all studies useful to man, theory and practice are related to each other by indissoluble bonds.

"Senseless the theorist who, shutting himself up in the solitude of his egotistical personal views, affects to disdain the incessant applications of science to civilization, for the wealth and happiness of mankind!

"Senseless, no less senseless, the practical man who, satisfied with the knowledge acquired by his ancestors, out of admiration for their conservatism and tradition, opposes all progress, refuses to enlarge or change the processes used in his industry, that it may remain each day in complete accord with the newest and most advanced theory!

"No science probably, more than chemistry, shows the necessity of this constantly renewed harmonious relation between practice and theory."

To-day the traffic of this great city, the incessant tide of travel, the lighting of its streets and homes, is effected by the aid of electricity generated by the burning of coal, and the specifications, under which the coal is bought, require that its calorific value shall be determined by the bomb calorimeter, invention of Berthelot, devised for theoretical purposes.

While a great theorist, he invariably had recourse to the experimental method for establishing his premises on a sure foundation. His temperament was that of an idealist, of a literateur, yet he foreswore in part his allegiance to science to serve his country.

France had honored him by the bestowal of many favors in recognition of his labors. Member of the Institut, 1900, grand officer of the Legion of Honor, 1880, perpetual secretary of the Academy of Sciences, 1889, succeeding Pasteur; but she also made him senator for life, 1881, gave him the portfolio of the Minister of Public Instruction and the Fine Arts, 1886, and made him Minister of Foreign Affairs, 1895, and he served his country with ardor.

The fiftieth anniversary of his first scientific publication was celebrated at the Sorbonne on Nov. 24, 1901. Official delegates of foreign scientific societies voiced their congratulations. The French Academy, in a stirring discourse delivered by Moissan, "tendered him its homage and thanked him for having given it a little more of truth." All departments of the government were represented at this unique festival. A beautiful medal, by Chaplain, bore on its face the likeness of Berthelot and the inscription, "La Synthese Chimique. La Science Guide l'Humanité." On the reverse side the savant appears seated before his laboratory table, on which is placed new classical apparatus, while above are two figures typifying the inscription "Pour la Patrie et la Verite," and the president of the republic, M. Loubet, as he handed him this gift, kissed the dear old man in token of the love and gratitude of the nation and in behalf of his admirers of all other nations.

Berthelot was particularly happy in his surroundings. He was constantly in his laboratories in Paris, Meudon and elsewhere; it was here that his *positive* science claimed him. In late years he resided in the Institut, a palace formerly occupied by Cardinal Mazarin. It was here, surrounded by his family and friends, that he enjoyed his *ideal* science.

He married early in life a beautiful and charming woman by whom he had five children, the four sons surviving. The forty-five years of married life came to a dramatic end. Both husband and wife suffered from heart trouble. Berthelot, anxious about his partner's failing health, was ever watchful. He left her to be present at the semi-monthly meeting of the academy, but returned shortly—only in time, however, to be with the beloved one in her last moments. Shattered by the blow he was led to a couch in his work room. Alas! The strain had been too great and his own heart, weakened by age and the present anguish, ceased beating.

On March 25 this noble man and woman were given public obsequies. The great Pantheon was filled with the representatives of all branches of the government from President Fallières down. The edifice was crowded with distinguished men and women. As the two bodies rested on catafalques M. Briand gave an eloquent discourse. Afterwards the body of Berthelot was placed on another catafalque before the church and the army passed in review, saluting the great dead. In the afternoon the public did him homage, and towards evening he and his dear wife were placed in the crypt, not far from the remains of Victor Hugo.

In his peroration to the second congress Berthelot summed up his views of life; he fulfilled them in his own: "Our duty is clearly outlined. Let us be doing, that is let us work! Work without cessation; let us try to be useful. Diligence and the love of mankind! This is the true aim of both home and public life."

The Moore Vacuum-Tube Light and the Luminosity of Gases

By C. J. Thatcher, Ph. D.

The past few years which have witnessed a rapid improvement in the arc and incandescent forms of electric lighting have also seen the commercial application of a new and distinct type of lamp; that is, the enclosed vapor or vacuum-tube lamp. Three forms of this type have become generally known. The first of these is the Cooper Hewitt, which is now widely used and well understood; a second is the Bastian, which like the former is a mercury vapor arc lamp, but of smaller dimensions and provided with an incandescent carbon filament lamp to provide red light rays; the third is the Moore vacuum tube. Since the latter has recently given evidences of commercial practicability and is perhaps not thoroughly understood, a brief description of it and consideration of its salient features will be given here. It will be shown, also, that certain phenomena observed in this tube may have an important bearing on the question of the nature of gaseous luminosity in general and one which has not been previously recognized.

Mr. D. McFarlane Moore began to experiment about twelve years ago for the purpose of producing a "cold light," that is, one in which all the electrical energy would be converted into light without any loss in the form of heat. At that time the maximum lighting efficiency was obtained with the arc lamp, consuming 1 watt per candle power. Dividing this value into the theoretical figure for the conversion of electrical energy into light as given by Dr. E. F. Roeber[1]—one spherical candle power per 0.115 watt—we see that only about 10 per cent of the electrical energy is converted into light in this form of lamp, the other 90 per cent is dissipated and lost in the undesirable form of heat.

Since then, however, illuminating art has been much improved, so that we now have a maximum lighting efficiency of 50 per cent in the flaming arc lamp, which consumes only 0.23 watt per candle power. The most efficient form of the Moore light, that is, the one in which rose-red light rays predominate, has a maximum efficiency of about ¾ watt per candle, and is but little better than that of the older form of

[1] Transactions of the American Electrochemical Society, vol. viii., page 248.

arc light. The heat loss is, therefore, about 85 per cent in the most efficient form of the vacuum tube lamp

Description of the Moore Vacuum Tube.

Although the "cold light" problem therefore is still unsolved, Mr. Moore's experiments have finally produced a novel and fairly efficient form of illumination, and one which possesses distinct advantages for some purposes. As it is now being installed it consists of a continuous stretch of 1¾-inch glass tubing of any desired length; this is supported near the ceiling by suitable brackets and encircles the room or space to be illuminated.

This continuous length of tubing is made *in situ* by joining together 6 or 8-foot lengths, and at the corners previously shaped angle pieces. The joints of the tube are made in the manner long used for joining large bore glass tubing in making chemical and physical apparatus; the blow-pipe employed is a slightly modified and movable form of that, having two impinging flames, which has long been used for that purpose.

The ends of the one-piece tube thus formed come together in a box about 2 feet square, which is suitably and inconspicuously placed. These ends are constructed of slightly larger bore tubing for a foot or so, and are, of course, rounded and sealed at their extremity. They each contain a electrode of carbon electrically connected with the exterior by platinum wires sealed in the end of the tube.

These wires in turn are in electrical connection with a transformer, which raises the voltage of the alternating current supply to 10,000, at which pressure the current is delivered to the tube.

Another essential part of the system, also placed within the box, is an ingenious vacuum regulator. This consists of a cone-shaped carbon pencil, sealed point upwards in the end of a narrow glass tube, sealed in turn to the main tube. Surrounding this carbon pencil and sealed to the narrow inlet tube which carries it, is a glass tube of larger diameter. The annular space thus formed contains enough mercury to cover the entire pencil, and in this mercury a metal tube displacer floats, attached at its upper end to the core of a solenoid placed above the regulator and in the lighting circuit.

The tube thus completed is evacuated by a Geryk or other mechanical vacuum pump to a pressure stated to be about 1/40,000 of an atmosphere. With the passage of the high-tension alternating current the tube immediately becomes luminous throughout, the light being a soft one with rose red rays predominating.

A suitable manometer was first attached to similar tubes several years ago, which, however, were not then provided with a pressure regulator. It was then found that the rarefaction of the gases in the tube slowly increased, and this was accompanied by perplexing resistance changes, which finally culminated in the failure of the light.

In order to secure a permanent light it has been found necessary, therefore, to admit very small portions of air to the tube at intervals. This is accomplished by the vacuum regulator which was devised subsequent to the measurement of pressure variations. When the air pressure decreases the internal tube resistance also decreases, more current flows through the solenoid of the regulator, and the core thereupon rises a trifle, withdrawing the displacer so that the mercury falls enough to uncover the tip of the carbon pencil.

This is thereby exposed to atmospheric pressure, and a small bubble of air, to which the pencil is not impervious as it is to mercury, filters through the carbon; the normal vacuum and resistance are thereby restored and the mercury rises again, shutting off the air supply. Practically normal tube conditions can be thus maintained indefinitely, and tubes thus automatically controlled have had a life of 1,000 hours or more.

The circuit is conducted through the Moore tube from terminal to terminal solely by the highly rarefied gases, and these alone are the source of the light it emits. The Moore light, therefore, is only a lengthened Geissler tube; its light may at times exhibit striated effects similar to those of this tube, but ordinarily these are not noticed by the eye.

Mr. Moore has, therefore, made a practical application of a mode of producing luminous effects which has long been known; which, indeed, was one of the earliest forms of light produced by electricity. Now that this form of light bids fair to have a commercial value it is to be expected that the nature of it may be the subject of more frequent, or at least more successful, scientific investigation, for strange to say little is definitely known concerning the source of the luminosity of conducting rarified gases.

Theories of Gaseous Luminosity.

It will be interesting to note here the theories regarding luminiferous gases recently advanced by different investigators in this field. The older theory is that the gaseous molecules send out vibrations of a visible wave length as a result of purely physical collision or heat effects consequent on electrical conductivity. Regarding this theory, Prof. H. A. Armstrong, in 1902, in an article on "The Conditions Determinative of Change and of Electrical Conductivity in Gases, and on the Phenomena Luminosity,"[3] stated: "An argument which I think will sooner or later be regarded as of weight in favor of the view that the phenomena are electrolytic in their origin is afforded by the luminous manifestations in vacuum tubes. These can scarcely be mere collision effects or mere heat effects. It has long seemed to me that luminosity and line spectra are the expression—the visible signs—of the changes attending the formation of molecules from their atoms, or, speaking generally, that they are the consequence of chemical changes, a chemical change being one which involves an alteration of molecular composition, or it may be of molecular configuration, as it is conceivable that even changes involving isodynamic (tautomeric) molecules—changes in molecular structure unattended with change in molecular size—may give rise to such manifestations." Prof. Armstrong believes gaseous luminosity to be the result of chemical activity therefore.

Prof. J. Stark, of Göttingen, on the other hand, who has made extended researches in this field, believes it to be a purely physical phenomenon, according to the following translated statement:[4] "The line spectrum of a gas has its source of energy in the kinetic energy of the particles of the ionized gas, its conduction in the positive ion atoms. * * * * The band spectrum of a gas, on the other hand, probably has its source of energy in the potential energy which the positive and negative ions possess in respect to one another, and which on recombination can be changed, at least partly, into light energy."

But a third authority, Dr. C. P. Steinmetz, in an address before the American Institute of Electrical Engineers, on "The Transformation of Electric Power Into Light," in November, 1906, stated regarding Geissler and vacuum tubes:[5] "The mechanism of this light production does not seem to be known, but the light seems to be somewhat of the character of a by product."

What May Be Learned from the Moore Light Concerning Luminous Gases.

It has not been recognized, so far as I am aware, that the observed constant decrease of gaseous pressure in the Moore tube may have an important bearing on the question as to the cause of the luminosity of the gases contained in the tube, and, indeed, of conducting gases in general. As has been already stated, it has been found necessary to feed the tube with air at frequent intervals. As a matter of fact very small portions

[3] Royal Society of London, Proceedings, 1902, p. 163.
[4] Physikalische Zeitschrift, 1905, p. 761.
[5] Proceedings of Amer. Inst. Elec. Eng., Nov. 1906, page 767.

are added every minute or so during use. This, of course, can mean nothing else but that chemical reactions are occurring which result in an increase of molecular size, and therefore in a decrease in the number of molecules and of the volume of gas.

The substances in the tubes in considerable amounts which might cause such reactions are, of course, nitrogen and oxygen and the carbon of the electrodes. Of the known reactions into which these might enter, those involving cyanogen formation, either as an intermediate or as an end product, cannot cause reduced pressure. The formation of ozone from oxygen, on the other hand, would cause reduction in the number of molecules and a higher vacuum. Ozone, however, is rapidly decomposed into oxygen again at temperatures below that of the interior of the Moore tube when in use, so that ozone cannot be a stable end product, nor can its formation cause the reduced pressure.

This leaves only the uniting of nitrogen and oxygen to form one of the oxides of nitrogen as the probable cause of the phenomena. The formation of NO and of N_2O_3 as end products would not result in reduced pressure, while that of N_2O, NO_2 or of N_2O_5 would. Of these, NO_2 is the more probable end product, but this investigation must, of course, verify.

It is true that solid brownish-colored deposits are frequently formed in the body of the tube; but is highly improbable that they are the products of reactions causing the observed gaseous contraction, for they are by no means invariably formed after prolonged use, and may, indeed, appear either very soon after installation or not at all. They are in all probability due, therefore, to impurities or variations in the composition of the terminals or of the glass tubing.

It seems certain, therefore, that the formation of one or more of these oxides of nitrogen is the cause of the reduced pressure of the tube. Apparently, Mr. Moore has come to the same conclusion—it may be by investigation—for he has often spoken of his light as one which "burns air."

Now, numerous investigations on the fixation of atmospheric nitrogen have demonstrated that the formation of oxides of nitrogen are purely thermal effects. (See Prof. Guye, this journal, 1906, p. 136, and Foerster and Nernst, Ibid, p. 256.) This being the case oxides of nitrogen will be formed in the tubes wherever there is sufficient heat development, and that is throughout the tube, since 85 per cent of the electrical energy put into the tube is converted into heat. Throughout its entire extent it becomes uniformly hot.

The heat development of the terminals is not appreciably greater than in the body of a tube, though bolometric measurements may show some slight difference. But this is certainly not considerable; so that in view of the far greater reacting volume of gas in the body of the tube it appears that the formation of oxides of nitrogen takes place in the Moore tube throughout its entire extent where it is accompanied by the emission of light.

The chemical actions here involved may not necessarily be direct ones. Ozone or other unstable but active molecular complexes may be concerned in it, and the reactions may be reversible and have low reaction velocities, but the sum total result of electrical activity in the Moore tube is, apparently, the formation of a stable oxide of nitrogen accompanied by and intimately connected with the continuous emission of light rays.

This conclusion is important in that its verification will furnish a practical substantiation of the theory of the chemical nature of gaseous luminosity advanced by Prof. Armstrong and already cited in this article. And verification is not difficult, it includes two steps: First, identification of the substances formed in a tube and an investigation whether the concerned reaction velocities are greatly influenced by heat. Second, an observation of the effect of temperature variations in the conducting gases on the candle power of the light which they emit, these temperature variations to be controlled by means external to the tube. If, for example, NO_2 is formed, and if the reactions producing it give rise to luminous effects, then cooling the tube to a very low temperature during its activity, *e. g.*, by liquid air, would lower the candle power, for the velocity of NO_2 formation is greatly retarded by reduced temperature (see Guye, Foerster and Nernst, loc. cit.).

The probable result of such an experiment is indicated by one cited by Prof. Armstrong. He states that Prof. Dewar, in an experiment before the Royal Institute, cooled a phosphorescent Crookes tube with liquid air and that its discharge at once ceased. Prof. Armstrong attributes this result to catalytic rather than thermal effects. If cooling to a low temperature produces similar effects in the Moore tube, as from the close analogy it may be expected it will, the dependence of the luminosity of a mixture of conducting gases on the velocities of gaseous chemical reactions will have been proven. This could not before have been proven, because only a vacuum tube as extensive as the Moore tube could give reaction products in amounts which could be identified.

Experiments such as suggested, if they verify the theory outlined above, will also teach several things about the Moore tube and vacuum-tube lamps in general. The first of these is, that in order to secure high-efficiency gaseous light-emitting reactions must be employed which are exothermic or whose reaction velocities possess a relatively low temperature coefficient. That is, it must not be necessary to change much of the electrical energy into heat in order to maintain the high temperature for a rapid reaction velocity, as is necessary in the formation of oxides of nitrogen. Or if suitable reactions of this nature cannot be found the necessary acceleration of reaction velocity must be secured by the use of catalytic agents.

The second conclusion to be drawn from the above theory—an inference, indeed, which is palpably evident from what is already known concerning the Moore tube—is that there is a limit to its life. Air is constantly admitted to the tube, enters into chemical reaction therein, and the reaction products *remain in the tube*. If gaseous they will gradually accumulate therefore, and ultimately extinguish the light by displacement of the active gases; even if they were solid they would coat the interior of the tube and make the light very inefficient. It is to be expected that the Moore tube will occasionally need repair, therefore, though the contrary seems to have been stated.

Advantages and Defects of the Moore Vacuum Tube Light.

Mr. Moore claims for his light a high efficiency, good actinic value, low intrinsic brilliancy, safety, perfect illumination without shadows and a very long life, indeed, that it will last for years without repair. The efficiency of the tube has recently been the subject of careful photometric tests by the New York Electrical Testing Laboratories, which showed that the average luces per unit energy were 20.0 for the Moore, 11.2 for the Nernst, and 3.6 for the carbon-filament incandescent lights, which is equal to .65, 1.1 and 3.5 watts per candle power, respectively. This efficiency is for the rose-red light only. In tubes emitting white light the efficiency is stated to be only about half the above, that is, 1.5 watts per candle power. This is not as high an efficiency, therefore, as is obtained with the metallic-filament incandescent lamps now being introduced.

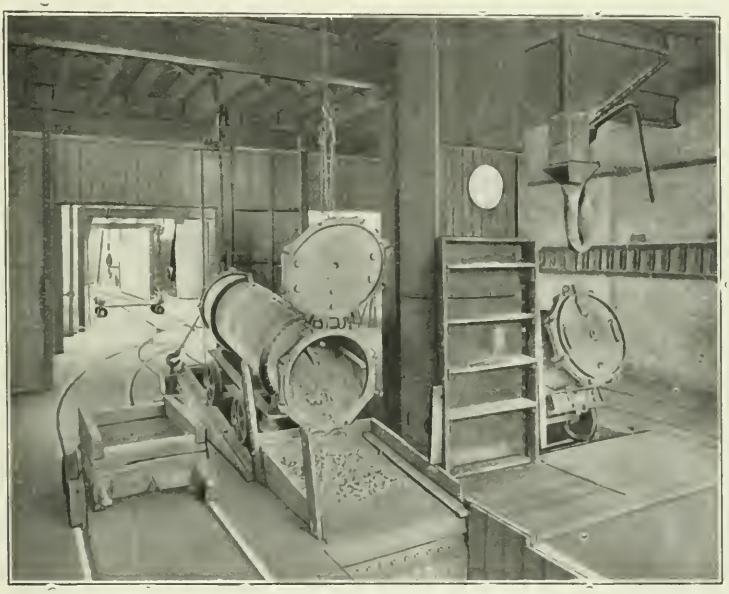
Mr. Moore at the present time rarely installs tubes giving a white light, probably because of their lower efficiency and unreliability; it is necessary to introduce other substances, and the tube conditions favorable to a long life or even satisfactory service are not yet thoroughly understood. The white light only is suitable for general use, of course, but the rose-red tint is satisfactory for exterior lighting and in rooms where proper color values are not essential.

The principal advantage of the vacuum tube is its low intrinsic brilliancy. Its light is but 12-candle power per linear

foot. It has no extremely bright portion common to nearly every other form of artificial light, which strain the eyes whenever they are in the angle of vision. This evil is now being lessened somewhat by the general use of frosted globes or shades, but even these do not bring these other forms down to as low an intrinsic brilliancy as that of the Moore tube.

The perfect illumination without shadows, that is, from every angle of the room, which has been claimed as an exclusive advantage of the Moore tube is equally well secured by the use of small units like low candle-power incandescent lamps suitably placed entirely around the sides of the room or on the ceiling at intervals of a foot or so. This method of installation produces the freedom from shadows quite as well as does the Moore tube.

The tubes are difficult to repair, and leave the room entirely without lighting facilities for a long time in case of a failure or accident to *any* part of the system. This fact, the high initial cost, and its want of what may be termed flexibility, that is, the impossibility of turning off or on at will a part of the tube illuminating any desired portion of the room, will militate against the rapid adoption of the Moore lamp for general illuminating purposes.



SHERARDIZING PLANT AT WILLESDEN, ENGLAND.

(Drums shown in loading and unloading positions. Note overhead zinc dust bin and screen upon which small articles are dumped, the dust falling through.)

Theory and Practice of Sherardizing.

By Alfred Sang.

If a disc of sheet rubber and a disc of sheet copper are placed in contact for a few weeks, the surface of the copper is found to have a heavy blue coating of sulphate of copper. The sulphur used in the vulcanizing of the rubber has, by simple contact, combined chemically with the copper. If for the rubber disc we substitute a disc of zinc, and insure perfect contact by pressure, we shall, after a few months, find the surface of the copper covered with a film of yellow brass.

An alloy is the combination of two or more metals, and while a great many persons still cling to the idea that fusion is necessary to produce an alloy, the extensive work of Roberts-Austin, Spring and many other investigators shows very conclusively that the inter-solution of metals may take place at any temperature. Alloying at a low temperature has the advantage of preventing the formation of eutectics, when particles of one metal are merely suspended in the other, and the internal stresses due to the uneven contraction of the mixture makes it valueless for most commercial purposes; the failure of bearing metals can, in most cases, be attributed to a complete or partial eutectic structure, due to careless manufacture.

If two metals in contact are both readily decomposed by the same agency, and if when in contact they are exposed to that agency, the metal which stands lower down the scale of electrical conductivity will be decomposed in preference to the other. This is the reason for the efficiency of a zinc coating for iron and steel articles and is distinct from the protection afforded by the covering as such. Moist air containing carbonic dioxide will oxidize both zinc and iron, but when they are in contact the zinc will bear the brunt of the attack. The closer the contact between the two metals the more effectual the galvanic protection will be, and the greater the exposed surface of the zinc is the more efficiently will it perform its self-sacrificing duty.

A heavy coating of zinc is not necessarily better as a protection against rust than a light coating. The thickness of the coating has little or nothing to do with the actual (galvanic) efficiency; it has, however, some bearing on the mechanical efficiency, and must receive consideration (apart from the Preece test) when, either the zinc oxide is constantly removed, exposing a clean surface to the action of oxidizing agents, and cannot be depended on to form a passive protecting film or when there is a certain amount of abrasion to be contended with.

The two most important desiderata in galvanizing are as follows: Firstly, intimate contact of the two metals. Secondly, as large an exposed surface of zinc as possible. The first can be attained, in a measure, in hot galvanizing by mechanical pressure, such as cold-rolling or wiping, and accounts for the

relatively high efficiency of properly wiped galvanized wire, hand and strip work. In most hot work spaces are left here and there between the zinc and the article coated, and oxidation will slowly proceed, out of sight, but none the less surely. The use of sal ammoniac as a flux is responsible for much of this class of damage.

The second desideratum is attained by giving a rough rather than a smooth surface to the zinc coating. A finely granulated surface may appear smooth to the eye, but it is rough in the sense which I mean.

Hot and cold galvanizing are too well known to describe again; I shall only refer to their distinguishing features when comparing them with the new process of dry galvanizing, which it is the purpose of this short article to discuss more especially in its theoretical aspects upon which must be built time, quality and cost improvements if such be possible.

Sherardizing owes its existence to the peculiar properties of zinc dust. Zinc dust (commonly known as "blue powder") is a by-product of the smelting furnaces; in the distillation of spelter from blende (Sphalerite) the amount of dust which sublimates in the flues will amount to perhaps 5 or 10 per cent of the yield of spelter. In this dust there are beads of pure zinc and a small amount of free oxide, besides traces of cadmium, lead, iron, etc., but it is mostly composed of impalpable particles of a blue-grey powder from $\frac{1}{40{,}000}$ to $\frac{1}{50{,}000}$ of an inch in diameter.

Every result I have so far obtained indicates that zinc dust is zinc in a very unstable state, due to the sudden cooling to which the minute particles have been subjected; each particle is a tiny zinc "Rupert's drop." The chilled surface of these apparently perfectly spherical particles is undoubtedly oxidized, and this is a very important fact in considering the theory of zinc-dust action. Inside, the molecules of the metal are packed without regular order, it is sub-crystalline, and these molecules are striving to adjust themselves in a more comfortable manner; this, however, cannot be done without bursting the shell in which they are confined, and the reaction of this catastrophe results in vaporization. Hence, at a temperature far below that at which the metal itself would be volatilized, the zinc dust is converted into a vapor of zinc with oxide.

The temperature at which zinc volatilizes is 940° C., and its melting point is 419° C., yet the zinc dust breaks into vapor in the neighborhood of 200° C., which, it is interesting to note, is about the temperature at which metallic zinc is so brittle that it can be powdered in a mortar. Zinc vapor reacts with sulphur. Twenty-five years ago Schwartz found that zinc dust and sulphur reacted when subjected to percussion; it seems to me that this indicates very clearly that the zinc dust is in an abnormal physical condition. So fine is the dew of this zinc vapor that the close-adhering deposit which it leaves on the inside of a test tube is iridescent in places, showing that its structural dimensions are of the order of light wave lengths.

If a closed receptacle is partially filled with zinc dust and heated to 200° C. or more the dust will break down into vapor or gas under considerable pressure. If metallic articles are immersed in the dust they will, after having been subjected to the action of the dust and its vapor for a period of 5 minutes or more, be found to have condensed some zinc upon their surface and in their pores. Zinc free from oxide will not give any result, and it must, therefore, be supposed that the oxide is reduced through galvanic action at the surface of the article, the free oxygen then combining with an equivalent of free zinc, the resulting oxide being in turn reduced at the surface of the article. Whatever the exact nature of the action may be the metal of the article seems to have its surface saturated with the vapor which is condensed after occlusion.

A light sherardizing shows a bright deposit, although it does not appear as such to the naked eye on account of its roughness, which is due to innumerable cavities or recesses which do not reflect effectively; this brightness suggests reduction. A heavier sherardizing is silver-gray, due to an outer coating of slightly oxidized zinc particles closely packed with occasional clusters which stand out from the surface. In the process of sherardizing contact with the dust is necessary, excepting under conditions which will be the subject of a future article when I am further advanced in my investigations.

The name of Sherard Cowper-Coles is familiar to all electrolytic workers. The salient trait of this versatile English metallurgist seems to be a gift for framing original deductions from common place observations; in other words, he is a "genius." The presence of some zinc dust in an annealing pot, and the silvery blemishes which an ordinary person might have passed over, if not without comment, at any rate without deduction, is responsible for a very surprising and valuable commercial application of the principles enunciated in the opening paragraphs of this article, principles which, by themselves, are of the type which inspire the most off-handed pooh-poohs of our average business friends.

In practice, sherardizing (as it is named after its inventor) is performed as follows: The articles to be coated are placed in a suitable retort—usually a cast iron drum—and covered with commercial zinc dust; the retort is closed as tightly as possible, and even luted, to prevent the egress of the vapor, which is at a higher pressure than the atmosphere of the oven (not to keep the air out as generally supposed).[1]

The retort is now placed in an oven and heated to a temperature of 300° C. or more; it has been customary to go by the heat of the oven, but this has little bearing on the process, it is the heat inside the retort which counts; the time during which the retort or drum will be left in the oven will depend on the deposit which it is desired to get. The retort is allowed to cool by natural means and the articles are taken out. By having two drums in connection with each furnace the operation can be made continuous. Drums can be revolved continuously or intermittently, but when the objects are not touching one another there is no advantage whatever in changing their positions.

At first sight it seems strange that the drum itself should not be coated; this is due to its higher temperature; it emphasizes the fact that we are in the presence of a case of condensation like that of atmospheric moisture on a cold waterpipe. In the patent drums used for electrolytic work, motion is necessary to coat the object evenly; in sherardizing each particle of dust may be likened to an anode from which zinc ions emanate. Vapor and osmotic pressures are, with few exceptions, mathematically identical, my comparison of the two processes is, therefore, not without some justification, and it will help the conception of what happens in sherardizing to keep in mind the properties of electrolytes. In one case the electrical energy is supplied from without, in the other case it is supplied from within.

Mr. Cowper-Coles has suggested that sherardizing may be due to cataphoresis (electric osmosis). There may be some truth in this, but judging by my own experiments I cannot see any more than a very natural mechanical action, combined with catalytic effects which are by no means uncommon. I have found that no action takes place unless the vapor be under pressure in a closed receptacle; not only is it impossible to coat a piece of metal immersed in dust contained in a dish and placed over a burner, but the presence of an unlimited supply of oxygen will cause oxidation of the dust in preference to its disintegration; if oxidation is out of its power the dust will break into vapor, the energy required for this being evidently greater than what is needed for producing oxidation.

The higher the pressure the more effectively will the zinc gas force itself into the metal, and the temperature at which the article should be to receive its deposit most rapidly depends, in my estimation, on the relative specific heats of the zinc vapor

[1] I have successfully operated a small retort with a hole in it through which the vapor blew out and ignited; there was no possibility whatever of air getting in.

and the metal of which the article is composed, at their working temperatures. Hydrogen, which is produced by an acid pickle, becomes occluded in the iron, forming a brittle alloy, and the gaseous component of this alloy can only be removed by baking; zinc gas acts in very much the same way, and once condensed it cannot be removed by any temperature short of the point of ebullition of zinc, which is 940° C.

There is no doubt about the combination of the zinc and the metal of the article being sufficiently intimate to be classed as an alloy. Copper which has been sherardized shows a skin of hard brass, and the blow-pipe is unable to form a bead of zinc on the surface of sherardized iron as it does when the iron has been hot or electrically coated; the temperature required to fuse the zinc-iron alloy is above that produced by the ordinary blow-pipe.

Micrographs show that there is a blending of the metals, and the old surface is lost and cannot be recovered by either chemical or mechanical means. It is never required that galvanizing be removed, so that there is no disadvantage in this fact, but very much the reverse, because there can be nothing more desirable than that the protection be due to the nature of the surface itself.

The longer the process is conducted the deeper will the vapor go into the metal, but in addition to this, condensation will take place on the surface in closely seried granules, and will increase the exterior coating of practically pure zinc which, with increasing purity, will grow softer as it thickens. The pressure in the retort is practically constant at constant temperature; as it is relieved by condensation of the vapor, the hottest dust particles break into vapor and re-establish the equilibrium.

Electro-galvanized work is readily buffed, but the polish is evanescent; it is too soft to stand any reasonable amount of wear, and it rapidly dulls by oxidation. This dulling is mainly due to the zinc being compelled to oxidize in order to protect the iron which is being continually attacked by the air which reaches it through the pores. All other conditions being equal, the oxidation of electro-galvanized coatings is a function of their porosity; spongy coatings, due to bad management, whiten with surprising rapidity. There are no pores in a sherardized surface, but apart from this the polish which can be given to the zinc-iron alloy is very nearly as hard as nickel-plating, and is very much superior as a protection. If nickel-plating is preferred it can be done over sherardizing instead of over copper. Polished sherardizing is of a better color than nickel-plating, it is bluish like silver and its reflecting power is higher; the difference in this respect is striking to the naked eye, but even more so when the two are viewed side by side under the microscope.

Commercially, sherardizing possesses many vital advantages over the older methods. The first cost of the plant is lower and the depreciation is very slight; it is quite simple and requires no special engineering skill. Weight for weight the zinc deposited costs less and it is more efficient. Irregular shapes and recessed pieces receive just as even a coating as the most regular. There are no residues such as dross, ashes and remnants of anodes.

The labor charges are small, and unskilled men can do the work, the most exacting requirement being the ability to read a pyrometer to within 50° C. Less care is required in cleaning the articles to be sherardized; oil will not produce blisters as in hot work, nor dust pin-holes as in cold work; in fact, oily articles receive a somewhat better finish. Threads of screws, bolts and nuts do not have to be recut and are thoroughly protected. Articles can be put into the retorts wet. The process can be worked intermittently and started quickly on account of the low temperature employed.

There is a considerable saving in fuel over the hot process in which several tons of zinc in each pot must be kept in a molten condition day and night and fifty-two Sundays a year. The cost of fuel is not as great as the cost of current in the electric process. Large articles do not have to be brought to the temperature of the zinc dust; in fact, the temperature of the articles has very little to do with the excellence of the result. No flux is needed, but the addition of a little charcoal is found to be beneficial; no supplies are used which in the matter of cost can compare with electrical supplies.

There is no danger whatever from explosion, no broken castings nor distorted iron work to replace. Curiously enough the temper of the finest steel blades is in no way injured, and sword blades which have been sherardized have stood the British army test of being bent back to the hilt. The temperature of sherardizing corresponds to pale blue, and it might be expected that, not being unlike sand tempering, all articles would be drawn to a blue. The truth of the matter is that we know as yet very little about what is going on inside the retort, and especially so in regard to temperature. The temperature of vaporization is so low and the condensation so rapid that it appears doubtful to me if the articles ever reach anywhere near the temperatures which have entered into our discussion. It is a case where we can readily mold our theories to agree with the results of experience.

Sherardizing is drawn down with the article—be it sheet, wire or strip—to which it is applied. A valuable feature of the new process is its adaptability to a great many objects which have not hitherto received such reliable protection from rust on account of the impossibility, either physical or economic, of doing so by means of zinc. Take fly-screening: hot galvanizing would fill the meshes and electro-galvanizing consumes too much current to apply it to such fine work. Harvester cutters and innumerable machined articles could be enhanced in value 100 per cent or more by having their lives lengthened by alloying the surface with zinc (galvalloying?).

An electrolytic flashing with zinc is valueless save for the inspection of surface flaws. A flashing by sherardizing is an efficient rust preventative. Slightly sherardized boiler tubes for the export market reach their destination uninjured by the sea air. Silverware which has been flashed before being polished will not tarnish through the action of H_2S. Sherardized aluminium can be readily soldered. In either case there is no change of appearance.

A very interesting application of sherardizing has been found in the production of damascened work of a novel and artistic kind. The process is simplicity itself. The article is coated with a stopping-off material, which is then removed wherever inlaying or onlaying is desired. It is then placed in an air tight box containing the dust of the metal which is to be alloyed, and the whole is heated for 10 minutes or longer, the tints and shading off at the edges depending on the duration of the operation, which resembles case hardening, excepting that metallic dusts take the place of carbon.

That surface alloying for the purpose of protecting against oxidation will some day be applied to large pieces, such as structural material and steel cars, is the author's firm belief, and for those who have not read between the lines of this article, he will publish the experiments and reasons upon which he founds his belief in some future number of the ELECTROCHEMICAL AND METALLURGICAL INDUSTRY.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

THE MODERN THEORY OF ELECTRICAL CONDUCTIVITY OF METALS.

From my March letter there was unavoidably held over for lack of space a reference to the paper which Prof. J. J. Thomson read upon this subject before a crowded audience at the Institution of Electrical Engineers. In a form of the theory which the author published some few years ago he limited the movement of the particles to the case of negative particles. He then supposed that the actual carriers of the electricity in the

metal were those small negatively electrified systems which he calls corpuscles, and which are called by others electrons (or electrons by Lord Kelvin), and that the heavier positive particles took but little or no part in the conduction of the electricity. This view has the advantage that the passage of electricity through a metal is not accompanied by any transport of the metal, a result which has often been looked for but never detected.

In the usual form of the theory, which I shall show later on requires some modification, the structure of the metal is somewhat as follows. By the action of one atom of the metal on another, corpuscles are split off from the atoms of the metal and they remain diffused through the mass of metal; so that we may picture to ourselves a metal somewhat like a porous body, the pores of which are occupied by a substance with the properties of a perfect gas. In the older theory it was supposed that these corpuscles remained free for a time sufficiently long to enable them to get into themal equilibrium with the metal itself, so that, like all gases, the average kinetic energy of the corpuscles was a constant merely depending upon the temperature.

With all gases, the average kinetic energy is the same if the temperature is the same. As these corpuscles are exceedingly small compared with the molecules of hydrogen, the mass of a corpuscle being only about 1/3400th part of that of a molecule of hydrogen, the corpuscle must move with very much greater rapidity than the hydrogen molecule at the same temperature; in fact, that the square of the velocity of the corpuscle must be 3,400 times the square of the velocity of the hydrogen molecule, with the result that the velocity of a corpuscle at 0° C. would be about 10^7 centimeters per second, or, roughly speaking, about 60 miles per second.

These rapidly moving corpuscles are supposed to be disseminated throughout the metal, and to be moving with this velocity in all directions. If there is no external force acting upon them, though there is this movement of electricity through the metal, yet there is no transport of electricity in one direction rather than in another. There are as many of these corpuscles moving in the one direction as in the opposite, so that there is no resultant flow of electricity.

But if we apply to these corpuscles an external electric force, then the corpuscles drift under the action of the force, drifting since they are negatively electrified, in the opposite direction to the force, so that a definite flow of these corpuscles now takes place through the metal, carrying with them the proportionate amount of electricity, and it is that flow which, according to this theory, constitutes the electric current.

Further on Prof. Thomson suggested that "the electric force, instead of acting on the corpuscles after they have left their atoms, really acts upon the atoms before the corpuscles leave them. Instead of the atoms acting on each other, think of a system of electric doublets acting on each other, and the corpuscles flows from one into the other. If you have all the doublets arranged higgledy-piggledy in the metal, then there will be as many corpuscles going one way as there are going the other; there will be no transport through the metal.

"But supposing the action of the electric force is, to polarize these doublets before so as to drag them into line, very much on the old view of Grotthus's chain and the old theory of electrolysis; supposing, for example, you drew them all into line with the negative ends pointing in one way and the positive in another, you would get a transport. When these corpuscles jump they would jump the same way, and you would get a definite transport of electricity through the metal. I think the modification that is required is to suppose that, when the electric force acts upon the metal, what is does is to arrange to a certain extent these atoms or doublets which are acting upon each other into a line, so that when they discharge the corpuscles from one to another, these corpuscles go in a definite direction."

Finally the Hall effect was discussed and explained in the following terms: "Suppose that we have a doublet with negative and positive ends, then if this is started moving by being pulled round by an electric force, these ends start moving in opposite directions; and if there is a magnetic field acting upon the thing at right angles to the electric force, then there will be forces acting upon these two ends. If those ends move with equal and opposite velocities, the forces on the two ends are equal; but if the velocities are different, then the forces on the ends are different and there is a couple produced; in fact, this thing, when placed in a magnetic field, behaves exactly like a gyroscope.

"Suppose that you had a pendulum, with a gyroscope bob instead of the ordinary bob; suppose it were in a position inclined to the vertical, corresponding to one of your doublets before an electric force acts upon it; supposing now you let it fall; gravity will not pull it straight down to the vertical as soon as the gyroscope begins to fall, but will cause it to spin round like an elliptic pendulum, one way or the other, according to the direction of rotation of the bob. So that if you had this gyroscope properly attached to a doublet; then when you attempted to pull it along the lines of electric force it would come out a little at right angles, and there would be a current either that way or the other way, according to the sign of what corresponds to the spin of the top of the gyroscope. So that, in addition to this movement along the direction of the line of force, you would get these doublets tilting up a little bit at right angles to it; there would be a polarization in the direction of right angles to it, and that polarization would produce a current in that direction; so that unless the negative and positive ends move with equal and opposite velocities—that is, unless the centre of gravity of the thing is exactly midway between the negative and the positive charge—then these molecules, when they are placed in a magnetic field, will be acting like gyroscopes, and if you attempt to pull them by a force in one direction, they tend to squirm off in a direction at right angles to it; and that, I think, accounts for the Hall effect in metals."

Only four speeches followed—probably because the specific inductive capacity of the brains of the members of the I. E. E. is very low in regard to physics. Lord Rayleigh and Dr. Glazebrook praised the paper. Prof. Silvanus Thompson asked sundry questions, and Sir William Preece seconded Dr. Glazebrook's proposal of a vote of thanks. In reply, Prof. J. J. Thomson dealt with some of the questions propounded and declared for the term corpuscle instead of electron, using the word corpuscle to denote a negative electron, and calling a positive electron by the double-worded name. The only drawback to the use of the word electron in both cases, was that it suggested an equality in their properties. For the rest, the speaker's exact words will bear quotation without any condensation:

"Then Prof. Silvanus Thompson went into some questions which if I could answer I should be very near solving the problem of the universe—the relation between electricity and matter, and whether a corpuscle was a bit of electricity or a bit of matter with a charge on it. I do not know what electricity is and I do not know what matter is. I have tried to state what I regard as energy. Taking the corpuscle, I think that all the energy possessed by a corpuscle is due to the magnetic field that it produces when in motion, or kinetic energy. I should like to ask those people who talk about electricity and matter to try to think for themselves what they mean by matter and what they mean by electricity. If they did so, they would not find it so easy to define the terms they mean. Then with regard to the question of the action of one atom upon another, I myself regard an atom as a collection of positive and negative electricity, not exactly neutral, but somewhat analogous to a magnet with positive and negative poles."

Market Prices in March.

The following closing prices have to be noted in the chemical trade for the end of March:

Copper sulphate, £33.2.6 per ton; shellac, £9.11 per cwt;

bleaching powder (35 per cent), £4.10 per ton; ammonia sulphate, £12.2.6 per ton. The coal tar products are slightly weaker, crude carbolic acid (62 per cent) being quoted at 1s. 8d. per lb., and benzole (90 per cent) at 7s. 3½d. Cyanides (98 per cent) are weaker at 7½d., having been at 8½d. on March 15. No changes are reported in regard to the soda products.

Copper prices have been an interesting study. Opening at £108.15 per ton, the high price of £110.10 was reached on March 12. Prices then fell away to £106 on the 19th, rallied to £107.5 on the 21st, and then, under pressure of the general fall in securities, receded to £97.10. Tin opened at £192, and remained in this neighborhood until the 14th. The price then broke to £186, and after a slight recovery receded further to £182 on March 25, rallying to £184.15 on March 30. English lead maintains its characteristically stolid level, opening at £20 per ton and closing at £20. Pig iron prices have been fairly well maintained. Opening at 55 per cwt. it has closed at 53.2½ per cwt., intermediate extreme prices being 57 on the 4th and 53.3 on the 13th. Quotations on March 30 were as follows: Hematite pig iron, 77; steel rails, £6.15; steel plates, £7.10 to £7.12.6.

As to the future, the large firms are said to be fairly well occupied, and good dividends have been paid. It is generally considered that the recent "flurry" in prices of raw material is due to the panic in certain securities and has no real basis in the reduction of manufacturing demands. Nevertheless, it must be remembered that the recent half prices of tin and copper have been a first-class incitement to increased production from new enterprises, and that supply in any period of trade activity does ultimately catch up with the demand, and then, outstripping it, inaugurates a period of depression.

London, April, 1907.

SYNOPSIS OF PERIODICAL LITERATURE

Metallurgy

Precious Metals.

The Computation of the Crushing Efficiency of Tube Mills.—The discussion of the paper of Pierce and Caldecott, which was recently abstracted in the synopsis, is reported in the *Journal* of the Chemical, Metallurgical and Mining Society of South Africa, January, 1907. Mr. E. Laschinger refers at length to a series of grading tests carried out with the product of the tube mills. For a further practical study of the problem of crushing efficiency he makes the following suggestions: 1. A grading analysis should be conducted with a sufficient number of screens. 2. All grading should be done with a set of standard screens having equal differences of aperture between them. The results of such grading would at once indicate the nature, as regards fineness, of the product which the crushing machines will produce under different conditions of operation, and what is the kind of product that may be expected from that class of machine. This information would be most useful in the designing of plants inasmuch as such crushing machinery could be installed as would give the highest percentage of that size of grain which is amenable to the treatment process decided upon. Furthermore, if the tube mill product were graded with a standard set of screens having apertures of 0.04, 0.035, 0.030, 0.025, 0.020, 0.015, 0.010 and 0.005 inch, it would be easy to tell by inspection the law of crushing for the tube mill when working under the conditions obtaining when the samples were taken. If the law of crushing were that of equal weights of particles of successive diameters, the percentage weights of each grade would be equal. It would also be at once apparent what particular grade was mostly being produced and it might be possible, between certain limits, by regulating the pebble load, rate of feed and speed of the mills to produce different degrees of fineness of reground product at will. 3. It is, of course, necessary to have a maximum aperture screen, slightly larger in aperture than the battery screen, so as to first eliminate from the sample of the material going to the tube mill any accidental particles due to broken screens, resetting of tiers, etc., and to eliminate from the sample of material leaving the tube mill worn out pebbles coming through the discharge plate. The slimes in the sample should, of course, be washed out before grading. 4. It is problematical whether woven screens with an aperture much less than 0.005 inch are at all reliable, because crimping and weaving seem to be irregular and the fine wires are easily displaced, thus giving great variations in apertures.

Cyanide Works Clean-Up Practice.—In the discussion of the paper by Mr. S. E. Thomas, formerly abstracted, W. R. Dowling (*Journal* of the Chemical, Metallurgical and Mining Society of South Africa, January, 1907), calls attention to the loss of gold which takes place at the clean-up or dressing of extractors owing to the high value of the solution leaving the boxes at these periods. He has overcome the possibility of the samples becoming salted by sampling the sumps periodically over the 24 hours and assaying daily at clean-up time as well as at other times through the month. When sampling an individual box over the first 3 hours of its run after clean up, results as high as 3 dwt. per ton have been found, as high indeed as the solution entering the box. Half dwt. values over 24 hours are common. Dowling believes that most of the value carried over is from mechanically suspended gold, which appears to redissolve quickly after leaving the box and results from small, rich particles loosely adhearing to the returned zinc becoming detached by the stream and chemical action. The system of circulating the solution to the box or pumping from the tail of a newly started box reduces the evil, but is not altogether satisfactory. He suggests the installation of an additional filter press, through which all solution leaving the newly started boxes should be pumped. To the solution before entering the press should be added enough zinc fume to precipitate any gold in solution as well as to keep the suspended gold from solution. The author also refers to some work he did in pot smelting in the ordinary reverberatory furnace with the object of reducing the loss of dusting in handling the calcined slimes received in the preparation for smelting. The preparatory operations consisted in first, crushing in a coffee mill; second, mixing with fluxes, and, third, transferring to the pots, and gold slime dust was produced in each of these. The loss of gold dust was avoided by the following procedure. After calcining and cooling, the tray of slimes was weighed and the previously ascertained weight of the tray deducted. The requisite amount of manganese dioxide was evenly spread over the surface of the slimes, and by means of a small, flat shovel with sides the slimes with complement of manganese dioxide were transferred to the pots. Any large lumps of slimes were crushed carefully in the pots by pressure only of a pestle. The borax and sand were added on top of the slimes and the pots were ready for fusion. On pouring, the slag was liquid, and after cooling and breaking up did not show any unfused lumps. The bullion was satisfactory and there was no excess of rills of gold in the slag, while the mixing in the pot during fusion appeared to be perfect.

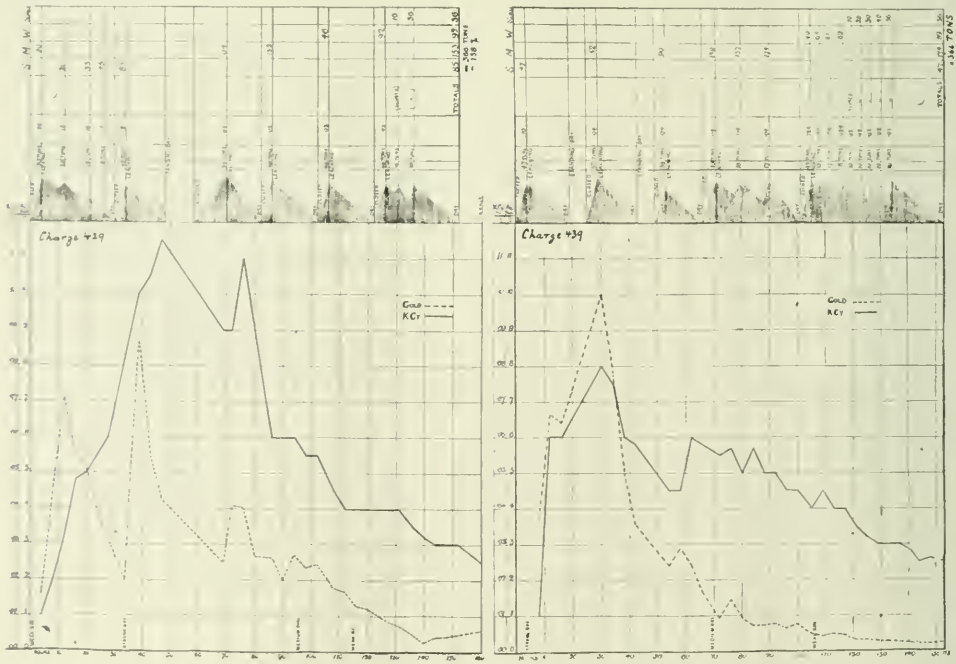
Colloidal Silicic Acid in Slimes.—W. A. Caldecott, in a communication to the *Journal* of the Chemical, Metallurgical and Mining Society of South Africa, January, 1907, attributes the difficulty during treatment by the decantation process of settling accumulated slimes or slimes from partly weathered pyritic ore when compared with current slimes from freshly mined pyritic banket ore to the formation of colloidal silicic acid. He assumes that the free sulphuric acid liberated by weathering pyrites decomposes any silicates of alumina or magnesia present with the consequent liberation of silicic

...or colloidal silicic hydrate. Thus, kaolin would be decomposed as follows:

$$Al_2Si_2O_7(OH)_2 + 3H_2SO_4 = Al_2(SO_4)_3 + 2Si(OH)_4 - H_2O.$$

The colloidal silicic acid formed in this way remains suspended for long periods in water or alkaline solutions in a gelatinous, spongy form and thus retards settlement of the non-colloidal slime particles. Similarly on leaching or filter pressing it retards the passage of solutions, but dehydration by drying, calcination or roasting corrects it into the non-colloidal state so that settlement or leaching can then go on freely. The writer adds that experiments made by adding a small percentage of artificially prepared silicic acid to current pyritic slimes showed a remarkable decrease of the rate of settlement in comparative trials. As kaolin is derived from the decomposition of feldspar, he considers it possible that clayey ore may likewise contain colloidal silicic acid liberated from the alkaline silicate present in the feldspar, by carbonic acid liberated from the air, and that the plasticity of clay is thus partly due to this cause.

Extraction of Gold from Cyanide Solutions.—The extraction of the values obtained on the Transvaal ores must be conceded as second to that on no other goldfield in the world, and the Rand has been justly famous for its advanced metallurgical practice. Efforts are, however, being constantly made to improve the extraction still farther, it having been calculated that an improvement of even as little as ½ per cent would represent a sum of more than $500,000 on the usual gold output of the Rand. Mr. H. A. White, before a recent session of the Chemical, Metallurgical and Mining Society of South Africa (*Journal* of the Society, February), dealt with the possibilities of increased extraction from the cyanide leaching solutions. In chemical operations the greatest washing effect is obtained in the case of a precipitate by allowing each portion of wash water to drain completely and to use no more than sufficient to cover the precipitate. This method, however, in the case of leaching cyanide sands cannot be adopted as it requires too much time. A certain amount of displacement is effected by the method of continuous leaching, and the most profitable compromise between it and the former one has to be determined experimentally by taking into account the cost and the values of the solutions leaving the tanks under the different possible methods of treatment. Mr. White gives the accompanying two diagrams, showing the gold and cyanide value of solutions, leaving two fairly representative charges of the same total weight of tonnage of solution (366 tons of solution to 230 tons of sand). The method adopted in charge 439 was based upon observation of results from charge 429, the endeavor being made (1) to reduce the cyanide consumption and (2) to keep the gold values in correspondence with the cyanide strength so that all the rich solution might be leached into the strong extraction boxes without the necessity of putting too weak solution in cyanide through these boxes or too strong a solution through the weak boxes. He points out that the diagram of charge 429 shows that the practice of commencing with a weak or medium solution is not to be commended except in special cases, not now under consideration. The first leachings on this plan begin to carry gold very soon and the cyanide strength lags behind too far. These leachings would have to go into weak boxes, and the author thinks that they are largely responsible for the formation of the objectionable white precipitate. In his view the precipitation of the latter depends upon no definite factors such as alkalinity or cyanide strength as far as actual practice is concerned, but solely upon the rate of change of these factors. A certain amount is held in solution definitely corresponding to alkalinity, or in the form of a double cyanide or zinc and potassium dependent on the cyanide strength. Temperature is also an important factor. Any reduction in the strength in these constituents will cause zinc compounds to be precipitated, and the aim should be to effect this in the tanks and not in the boxes. If these premises are true then it follows that the first drainings from the sand tanks, which carry practically no cyanide or alkalinity, must not go to a weak box where they mix with solutions nearly saturated with zinc, and so reduce their pro-



tective strength to the point where zinc hydrate falls out. These solutions must go to either strong or medium boxes, where their lack of strength is counterbalanced by solution flowing from other tanks under treatment and the danger point is not reached. To effect this with minimum loss the new tank must be started by a saturation with strong solution, and a gain of time is also effected by this method, as appears from a comparison of the diagrams.

Treatment of Auriferous Ore Containing Insoluble Arsenides.—In a paper read before the Chemical, Metallurgical and Mining Society of South Africa, published in the *Journal* of the Society February, 1907, Mr. J. K. Wilson outlines experiments undertaken with arsenic bearing tailings of an auriferous South African ore, with a view to reduce the cyanide consumption in their treatment. The arsenic contents of the tailings are due to arsenical pyrites in the ore, the bulk of the gold being free and fairly coarse and amenable to amalgamation. No concentration is attempted, as the quantity is too small and the value of the concentrates too low. Both accumulated and current tailings are treated by the cyanide process. An analysis of the tailings shows the following composition: SiO_2, 36 to 40 per cent; Fe_2O_3, 40 to 43 per cent; Fe_3O_4, nil to 2 per cent; Al_2O_3, 11.8 to 12.5 per cent; arsenic as arsenide, 2.05 to 4.7 per cent., S, 0.2 to 2.0 per cent; Sb, nil to heavy traces; Cu, nil to traces; acid salts, nil to 0.087 (H_2SO_4). Experiments, which are set forth in detail, were conducted to ascertain the action of the ore on solutions of alkali as well as on cyanide solutions with the following results: (1) The consumption of lime by the ore is due principally to the presence of arsenic which exists in the form of arsenides insoluble in water. (2) These arsenides act slowly on the alkalies, decomposing them, and the stronger the alkaline solution the more rapid and complete is the reaction which takes place. (3) Cyanide solution also dissolves these arsenides and is decomposed by them. (4) Arsenic may be practically precipitated from cyanide solution by the addition of Ca $(OH)_2$ in excess, some of the cyanide being regenerated, and such precipitate is more or less soluble in excess of neutral or slightly alkaline cyanide solution. (5) The presence of zinc, arsenic or other base metals in cyanide solution retards its solvent power for gold. From these facts it seemed feasible, provided that the compounds formed with lime and arsenic were less soluble in cyanide solution than the arsenical compounds already existing in the ore, to apply the lime to the ore first and to allow a complete reaction to take place before adding the cyanide solution, and that by thus proceeding the latter would be less liable to be attacked than if the lime and the cyanide solution were added together as had been the method of treatment adopted up to the time of the experiments. The method was, therefore, changed along the lines suggested and has led to greatly improved results. In the case of accumulated tailings the requisite amount of lime is fed into each truck as the vat is charged, the charge being then saturated with water and allowed to soak for about 24 hours. The water is then drawn off and cyanide solution of a strength of from 0.04 to 0.06 per cent is run on, this strength of solution is maintained throughout the treatment, and after each wash the charge is leached dry. The required amount of solution is about 3½ to 1 of ore; the time of treatment is from 8 to 12 days. When current tailings are treated the requisite amount of lime is added in the mill. The results of treatment under the old method were as follows: Amount treated, 1,832 tons; assay value before treatment, 3.07 dwt. per ton, assay value after treatment, 1.461 dwt. per ton, total gold contents of tailings, 304.29 oz.; total gold contents of residue 133.83 oz.; theoretical recovery, 230.46 oz., equivalent to 63.26 per cent. Fine gold actually recovered, 194.68 oz., estimated gold remaining in zinc, 25.00 oz.; actual recovery, 53.44 per cent; cyanide consumed per ton, 1.95 pounds; lime consumed per ton, 13.50 pounds; average time of treatment, 12 days. The improved results on adoption of the new method are shown by the following data. Amount of tailings treated, 1,853 tons; assay value before treatment, 4.40 dwt. per ton, assay value after treatment, 1.143 dwt. per ton, total gold contents of tailings, 411.30 oz.; total gold contents of residues, 105.09 oz.; theoretical recovery, 305.37 oz., equivalent to 74.23 per cent. Fine gold actually recovered, 300.01 oz., actual recovery, 73.03 per cent; cyanide consumed per ton, 1.45 pounds; lime consumed per ton, 11.00 pounds; average time of treatment 9 days.

Removing Broken Stem Ends from Stamp Heads.—The use of an hydraulic press for removing broken stem ends from heads instead of the old practice of knocking the ends out by hammers or blowing them out by dynamite is gradually being adopted and is no doubt much more advantageous than the former methods. Sometimes, however, especially with heavy stamps, the stems stick very tight. Mr. Q. C. McMillan, in the *Journal* of the Chemical, Metallurgical and Mining Society of South Africa, February, describes his method for removing such stems which would not move with a pressure of 140 tons. He applied the heat of a blow lamp, so as to expand the metal sufficiently to enable the press to do the work. The application of the blow lamp for a few minutes was sufficient to enable the press, whose limit was 140 tons, to squeeze out the broken ends with half the pressure previously applied unsuccessfully. The blow lamp has also proved extremely useful in loosening cams, both of the keyed and the Blanton pattern.

Clarifying Cyanide Solution for Precipitation.—In a communication to the *Journal* of the Chemical, Metallurgical and Mining Society of South Africa, February, Mr. W. S. Mann briefly describes the method he adopted for clarifying cyanide solutions for precipitation when treating dust from a dry crushing plant in Mexico with which he had considerable trouble in obtaining a clear solution. As settling tanks give poor results, and a sand filter was unsatisfactory owning to the fineness of the only sand available. In order to obtain a clear solution he placed common oakum, such as is used for caulking tanks, in two individual zinc boxes, allowing the solution to pass through from the bottom as with the other compartments, which were filled with zinc. This procedure gave a perfectly clear solution. To clean, the solution was first turned into the second compartment. The solution in the first compartment was then drained into a bucket and passed through the second box, after which the oakum was easily and quickly cleaned by kneading with the hands and rinsing with clear water.

Treatment of Cyanide Precipitates.—Mr. L. Bullock, in *Mining and Scientific Press* March 16, describes an interesting variation of the usual method of dealing with the product from the zinc precipitation boxes, in use at Copala, Sinaloa, Mexico. The precipitation boxes have eight compartments with bottom discharge valves. The slime is run into a two compartment screening tank, and the precipitate, which contains from 18 to 20 per cent moisture is then brought into a dryer, which consists of an iron cylinder 30 feet long by 30 inches in diameter, having an external fire box. A car, 24 feet long and holding six portable steel trays containing the precipitate, is run in on a track. The moisture is reduced in this dryer to 5 per cent and the precipitate then goes to a mixing box, where the flux and binder are thoroughly incorporated. The mixture is then pressed into briquets in a Smith briquetting machine of the E. W. Bruton Co. Only the No. 300 crucible is used for melting, a unit charge consisting of 250 pounds precipitates with its flux. As the briquets melt down more are added until the crucible has its full charge. No dusting takes place. All zinc shorts are returned to the boxes, and thus the acid treatment is entirely dispensed with. The boxes are filled by first putting, say, 2 inches of long zinc on the trays of the first section of the precipitation boxes, then lightly laying the short zinc on top to a depth of 15 inches, and alternating in this manner until the section is half filled. The boxes are then filled entirely with carefully placed long zinc. The briquetting

powder dusts well with the exposure of calcining, as the product is found to only 5 per cent moisture. This product is claimed to be in every way safer and cleaner to handle, and no spitting or dusting occurs in the crucibles. The capacity of the latter is also greatly increased unless the unsatisfactory practice is followed of adding the dry calcined powder to the later which obviously gives use to more or less dusting.

Iron and Steel.

Alloys with Arsenic.—K. Friedrich, professor at the Freiberg Bergschule, publishes in *Metallurgie* for March 8, an interesting study of iron-arsenic alloys (or compounds?) in the range from 8.4 to 56 per cent arsenic. By melting together iron powder reduced by hydrogen with a great excess of metallic arsenic 99.77 per cent pure, in a clay crucible at temperatures of 1,100° to 1,150°, alloys were produced up to 56 per cent arsenic. Remelting of this alloy with a great excess of arsenic, both in the crucible and in an electric furnace, failed to produce alloys richer in arsenic. The mineral löllingite corresponds to the formula $FeAs^2$, containing 72.8 per cent arsenic, and on heating splits up into FeAs and As, the former containing 57.2 per cent arsenic. It is thus evident that Friedrich obtained synthetically quite nearly the compound FeAs.

The melting point diagram showed the following phenomena. Alloys from 8.4 to 30 per cent, arsenic showed a setting point, falling from 1,384° to 830°, respectively, all, however, showing a halting point at 830° to 836°. These data show these compositions to consist of crystals of iron, or iron and a little arsenic, with the very well-marked eutectic of 30 arsenic — 70 iron, melting at 836°. With over 30 per cent arsenic the eutectic persists, mixed, however, with the compound Fe^2As (40 per cent arsenic), which melts at a maximum on the curve of 919°. Above 40 per cent arsenic the melting point falls slightly and then rises, evidently towards the melting point of the compound FeAs, with 57 per cent of arsenic, melting at 1,027°. The eutectic in this range has a melting point of 796°; but the data are somewhat confused by intermediate mixed crystals separating out.

Taken altogether, Prof. Friedrich has proved the existence of the compounds Fe^2As and FeAs, with a very strongly marked eutectic at 30 per cent arsenic, having the theoretical composition $Fe^{0.7}As$, or nearly Fe^3As. The study of the rich alloys shows the probable existence of Fe^3As^2, produced by a chemical reaction during slow cooling at 800°. None of the alloys investigated liquated; those with over 40 per cent arsenic were not attracted by the magnet.

Piping.—In a 106-page paper, on "Piping and Segregation in Steel Ingots," Prof. Henry M. Howe attempts to collate all the phenomena and their attempted explanations, and also brings forward some new ideas as to the why and wherefore of a "pipe." The paper was read first by title at the London meeting and at the recent New York meeting of the Institute of Mining Engineers.

Concerning the primary cause of piping, the author infers that it is "the virtual expansion of the outer walls of the ingot in the early part of freezing." Consider the ingot while freezing to consist of a relatively cool outer shell, a much hotter inner shell and a liquid interior. The outer shell is kept larger than it would be if cooling alone, because of the resistance of the inner shells, that is, it is virtually expanded. As the inner layers cool, being welded fast to the expanded outer shell, they do not change their outer dimension but contract all away from the inside. It is this contraction of the just solidified inner layers, towards the outside layer and away from the interior, which causes the pipe. Prof. Howe elaborates this statement and analyses the reasons therefor into some fifty-two pages of print.

Shortening of the pipe may be accomplished by a number of devices, such as casting in wide instead of narrow moulds, using thinner walled moulds, or moulds lined with sand, so as to reduce the great chilling of the outer layers and their consequently large virtual expansion. Deterring the cooling of the top of the ingot tends to raise the segregation towards the top and to shorten up the pipe. Casting with the wide end of the ingot uppermost also shortens the pipe; in fact, Howe makes a strong appeal for the commercial introduction of casting in this manner. Liquid compression reduces the pipe by distributing the contraction of interior volume over the whole section of the ingot. Blow-holes take up some of the room otherwise represented by the pipe, and therefore diminish the volume of the pipe.

As regards segregation, it is pointed out that the segregate is lighter than the rest of the metal, and tends to rise in the pipe; that its rising is retarded by compression of the upper part of the ingot, but facilitated by compressing the middle, such as in Illingsworth's system. Top casting is also better in this respect than bottom casting, casting slowly and at as low a temperature as practicable has a like effect. It is recommended that for high quality steel it be specified that casting be done from the top, with large end up and with a sinking head.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Electric Heating for Further Increasing the Temperature of Molten Materials.—F. Wynne, 848,422, March 26, 1907. Application filed June 23, 1905.

Details of a method by which material that has been heated to a red heat or to a higher temperature and thereby rendered molten or semi-molten, can be further heated while flowing from one receptacle or place to another, "as from a furnace or melting pot to a ladle, casting mold, rolling table or distributing trough or runner or from a ladle to a mold, rolling table or distributing trough or runner." The object is, of course, to reheat or superheat the molten material during its flow, so as to counteract the cooling effect of the air. Fig. 1 shows the arrangement by which a stream *b* of red-hot molten metal is electrically heated during its passage from a melting furnace *a* into a ladle *c*. The electrode *d'* in the ladle wall and a suitably-arranged electrode *d* in the spout of the melting furnace are connected with a source *e* of electric energy.

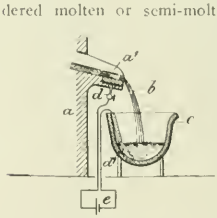


FIG. 1.—SUPPLEMENTARY ELECTRIC HEATING.

Electrolytic Processes.

Battery of Electrolytic Cells. Robert H. F. Findlay, 850,867, April 16, 1907. Application filed Jan. 12, 1907.

The cell is divided by means of two diagrams into three compartments. The middle compartment is called the electrolyte chamber. The two other compartments contain the electrodes, and are called the anode chamber and the cathode chamber. The electrolyte chamber is supplied with electrolyte through a suitable inlet and preferably under regulated pressure. The electrolyte passes from the electrolyte chamber through the diaphragms into the anode and cathode chambers, which are fitted with suitable outlets for the products of decomposition of the electrolyte. In practice, the inventor builds up a number of such cells into a single battery, mounting them within a frame somewhat after the manner of an ordinary filter press with tightening gear to press the several cells together. When the cells are built up into a battery in this

way, instead of providing each cell with a containing vessel or case he sometimes finds it convenient to machine off the sides of the plates constituting the electrodes and the diaphragms at their outer edges and puts in distance pieces at these parts, so that the spaces within these distance-pieces and between diaphragms and electrodes shall constitute the chambers or parts thereof hereinbefore referred to. In a preferred form he makes the anodes of a number of rods or other shaped pieces of carbon, clamped or otherwise held by plates of wood or other insulating material and the cathodes of plates of iron, preferably provided with grooves, corrugations or their equivalents. The pressure in the electrolyte chamber is made greater than that in the anode or cathode chamber.

Anode for Electroplating Cells.—George M. Elliott, 850,823, April 16, 1907. Application filed May 7, 1906 (assigned to Zucker & Levett & Loeb Co.).

The anode has at its top a transverse bar or head from which depend a series of teeth or columns which represent the anode proper. Attached to the upper side of the head are a plurality of ears or lugs by which the anode is suspended within the cell. The teeth of the anode are slightly tapering toward their lower ends.

Discharges Through Gases.

Nitric Acid from Air.—Albert Neuburger, 850,392, April 16, 1907. Application filed Dec. 24, 1904.

One of the great difficulties in producing nitric acid by means of electric discharges through air is due to the fact that in general nitrous acid is produced together with nitric acid. The present inventor states that the percentage of nitrous acid diminishes with the diminution of the power employed within the primary circuit (which contains the primary of a transformer, the secondary of which is connected to a spark gap). "If one were to employ, for example, a power of 200 watts and over, a mixture of equal parts of nitric and nitrous acid would be produced, so that consequently 50 per cent of the latter would be present. When using a power of 150 watts the percentage of nitrous acid sinks to 30 per cent. On using 120 watts it amounts to only 18 per cent. In this manner a gradual diminution of the percentage of nitrous acid takes place exactly with the diminution in the power employed, and when a very small power is employed the production of nitrous acid completely ceases, and pure nitric acid is formed." The first claim relates to "the process of oxidizing nitrogen, which consists in subjecting a mixture of nitrogen and oxygen to the action of an electric arc employing a maximum energy of 120 watts."

Batteries.

Composite Metal.—T. A. Edison, 850,881, April 16, 1907. Application filed March 30, 1905.

The "composite metal" consists of two or more metals physically admixed in such a way that "each metal exists as a practically integral sponge-like structure, the cells or pores of either metal being completely filled by the body presented by the other metal, whereby the entire bulk of the composite structure as a whole is continually solid throughout." The mixture of the two metals, however, is not so intimate or molecular as in alloys. By treating such a composite metal with an acid which dissolves only one of the two metals, this is removed and there remains a spongy integral mass of the other metal. Mr. Edison uses such a composite metal for the production of scales, flakes or foils of nickel and cobalt for admixture with the active material in the negative electrode of his storage battery. The method of manufacture is as follows: To a solution of sulphate of nickel and sulphate of cobalt he adds a potash solution in excess of that necessary to precipitate the two salts. The solutions are then boiled, resulting in the precipitation of hydroxides of nickel and cobalt, which are allowed to settle. The solution is now drawn off and the precipitated hydroxides are washed. The mixed mass of hydroxides of cobalt and nickel is dried and screened into granules of substantially uniform size. The granules are reduced in a hydrogen atmosphere in a heated retort. The reduced metallic granules are then subjected to successive rolling operations with oil to convert the composite metal into fine scales or flakes.

Secondary Battery Plate.—L. N. J. Roselle, 850,788, April 16, 1907. Application filed Feb. 13, 1905.

The first claim relates to "the process of manufacturing plates for secondary electric batteries, which consists in casting or molding in a mold a core of active material, casting around said core, while being in hot condition a ramified grid in a second mold, at the same time forming on the entire surface of said core between the ramifications of the grid a thin film of metal, then allowing the whole to cool slowly and finally removing the thin film of metal."

Battery Plate Holder.—W. G. C. Krause, 848,559, March 26, 1907. Application filed June 24, 1905.

Constructional details of supporting frames for the negative (specially copper oxide) plates of primary batteries. Claim 4 refers to details of a battery plate holder, comprising "the combination with a cover of a U-shaped wire frame attached thereto, a U-shaped gate member hinged to said U-shaped frame, a plate intermediate said U-shaped members and means to lock said gate in its closed position against the plate."

Battery Receptacle.—H. P. R. L. Poerschke and G. A. Wedekind, 843,549, Feb. 5, 1907. Application filed July 25, 1904.

Details of construction of receptacles for cells made of cast iron, bronze, copper or steel, the walls and partitions of which are so shaped as to afford support to the reducing agent, for example, copper oxide. The first claim refers to a "battery-container electrode, having walls of cast iron bulging outwardly to cooperate with the opposite electrode, a plurality of dovetailed-holding projections formed on the inside of said bulging walls and hardened, coherent copper oxide material on said walls engaging said projections forming a substantially flush surface."

Zinc Electrode.—C. B. Schoenmehl, 848,570, March 26, 1907. Application filed Nov. 16, 1905.

Details of mechanical construction of cylindrical zinc electrodes for batteries. The third claim refers to "a battery electrode comprising a cylindrical zinc having one or more poles formed integral therewith extended beyond the main body of the zinc, suspending-rods partially inclosed in said poles and zinc in a way to be protected by the same, and hardened shoulders upon the rods to engage the under side of the cover."

Vent Valve.—F. J. Schalow, 844,755, Feb. 19, 1907. Application filed Sept. 28, 1906.

Details of construction of a vent-valve for "wet batteries," in order to allow any accumulated gas to escape without loss of electrolyte.

Primary Batteries.—Frank A. Decker, 842,389, Jan. 29, 1907. Application filed Feb. 27, 1904.

Another patent relating to the Decker battery. The object is to provide improved mechanism adapted for readily filling and emptying a nest of battery cells, to permit the ready removal and replacement of the several cells, and to prevent leakage of current or its passage from one cell to the other, either through the supply conduit or the battery fluid contained therein." The second claim reads: "A battery comprising a plurality of cells, a duct extending into the interior of each of said cells, a main conduit, a plurality of branch conduits, each communicating with said main conduit and with a plurality of said ducts, and means for removing and replacing the respective cells and their ducts independently of the remaining cells and their connections."

RECENT METALLURGICAL PATENTS

Pyrite Smelting.

Hot Blast. The special feature of a hot-blast smelting furnace for sulphide ores, patented by C. W. Munson (846,498, March 12, 1907), lies in the fact that the hot blast is delivered into a confined circular air space or annular chamber which circles around the entire body of ore on the furnace hearth. In this way the air is evenly distributed against the exposed surface of the ore body instead of driving the air into the ore at separate twyer openings. The twyers are protected from the molten mass by this circular air space. The construction of the furnace is shown in Fig. 1. A suitably supported hearth is represented at 20, its wall 21 being formed with a discharge hole 22, through which the molten product passes to the spout 23 for tapping it off. The metallic portion of the furnace is supported on the wall and is composed of a plurality of removable sections, each of which is hollow to form a water-jacket. Each water-jacketed section comprises an upper portion 25 and a lower portion 26 at an obtuse angle thereto, so that when six of such sections are assembled the lower portion of the chamber enclosed by the sections flares or spreads outwardly, thus giving an enlarged hearth area with inwardly-sloping upper walls. Therefore, when ore is piled on the hearth, even to a height that will reach the angle *x*, the natural incline of fall of the sides of the pile or heap of ore will not reach the inner surface of the sloping walls. The inclined or flaring portion is formed with a twyer-opening to receive the air blast through tubes or nozzles 28 from a suitable source of supply of heated air, such as a hot-air box 29 surrounding the brick part 30 of the furnace resting on the metallic sections. It will be seen from the diagram that there is always preserved a free air space between the surface of the fused mass and the mouth of the twyers the blast is driven into the air space just inside the twyers and is continuous and encircles the entire ore body. The result is said to be that the blast penetrates the surface of the ore body evenly, and is distributed uniformly and carries down the values into the matte or slag.

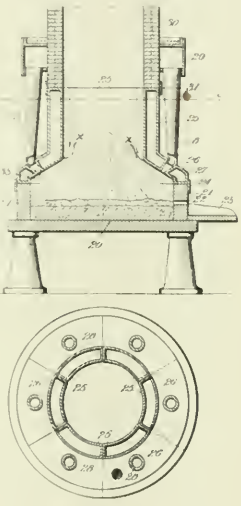


FIG. 1.—HOT-BLAST FURNACE.

Iron and Steel.

Self-Hardening Steel.—James Churchward (845,757, March 5, 1907) patents the following composition: 94.6 per cent steel (having in it 0.6 per cent carbon), 3 nickel, 1.5 chromium, 0.25 manganese, 0.5 tungsten and 0.15 vanadium. "It is believed that the alloying elements react on each other to produce chemical and molecular changes of such a nature that the tungsten, chromium and manganese are permitted to harden the steel, while the vanadium removes or prevents brittleness and imparts toughness without softening the alloy."

Lead.

Lead Oxide.—A process of making lead oxide, for use as pigments, which is stated to be quick in operation and yield a pure product of superior quality, is patented by John W. Bailey (840,444, March 12, 1907, assigned to United Lead Co.). The process is based on the fact that finely divided metallic lead which may be produced by blowing a jet of steam or compressed air through a stream of molten lead, can be further reduced to a very fine dust or impalpable powder by means of a suitable pulverizing or attrition mill, and can then be quickly and economically reduced to the state of an oxide by being exposed to the action of a current of hot air and moisture. The pure product thus obtained is ready for use without further treatment, such as grinding, washing, etc. The inventor describes a suitable pulverizing mill adapted to reduce comminuted metal to an impalpable powder. This powder is then introduced into an apparatus consisting of several closed muffles in series through which it is passed with the aid of agitating devices from end to end. Each muffle has one passage for air supply, and in order to supply the moisture a steam jet is arranged in each air-supply passage, so as to act at the same time to induce the current of moist air through each muffle and to suitably heat the air as it is introduced.

Zinc.

Treatment of Lead and Zinc Sulphide Ores.—To convert sulphide ores of lead and zinc, together with silver, into chlorides, it has been proposed to suspend them in a bath of fused zinc chloride or of a mixture of chlorides of zinc and lead, and to subject them therein to the action of chlorine or of sulphur chloride. But this treatment involves a loss of zinc chloride by volatilization when the fused mass is heated to the vaporizing point of sulphur, and it is impossible to treat by this process ores which contain more than 30 per cent of gangue, by reason of the lack of fluidity of the resulting pasty mixture. O. Fronek (845,868, March 5, 1907) proposes to add sodium chloride to the fused bath so as to form with part or all of the zinc chloride a double salt. Then follows the treatment with chlorine or sulphur chloride. This bath has, in comparison with zinc chloride, a lower melting point but a higher volatilizing point. This not only insures that no zinc chloride shall be lost when the temperature is raised to a point sufficient to volatilize the separated sulphur, but it permits the initial fusion of the bath to be accomplished with relatively little difficulty. The bath is comparatively very fluid and mobile. This not only facilitates the distribution of the gaseous chloridizing agent, but permits the treatment of ores containing a relatively high percentage of gangue.

Copper.

Hardening Copper.—R. T. Anderson (845,606, Feb. 26, 1907) tempers copper articles to various degrees of hardness by placing them in white sand, surrounded by sheets of zinc, also embedded in the sand, and by heating the whole. The amount of volatilized zinc which is absorbed by the copper determines the degree of hardness of the latter.

Aluminium.

Soldering.—To solder aluminium by means of tin, R. A. Hall (845,948, March 5, 1907) uses a soldering compound consisting of 60 per cent stearic acid, 25 mutton tallow, 10 pure lard, 5 paraffin wax. These are melted together, allowed to cool and granulated. In order to solder aluminium the contact surfaces are cleaned by scraping, the compound is then applied and acts as a flux, the soldering being done with an ordinary soldering iron.

Thermit Welding Process.

A very handsome pamphlet, illustrated by strikingly attractive half-tones, has recently been issued by the Goldschmidt Thermit Co. on their well-known thermit welding process and "what it offers to transportation companies," in enabling quick repairs and avoiding expensive delays. The illustrations show thermit repairs of shafts, stern-posts, propeller-bearings on steamships, thermit welds of broken locomotive frames, etc.

Electricity at Jamestown.

Electric power for the approaching exposition at Jamestown, like that of the Buffalo Pan-American Fair, will come from a distance. Having no Niagara to rely upon, however, power for the Jamestown Exposition will be furnished by steam turbines located in the powerhouse of the Norfolk Railway and Light Co., about seven miles from the exposition grounds. This fair will be the first at which the electric power will be generated by steam turbines. The machines will be of the Curtis type, these as well as the complete electrical equipment being supplied by the General Electric Co.

The exposition authorities have entered into a contract with The Norfolk Railway and Light Co. to furnish all the electricity required for illumination and power purposes. The electricity generated at their Jamestown power-house will be transmitted on specially construc ed lines to a model sub-station in Machinery Hall. Here will be located the transforming and distributing apparatus. This equipment consists of large air-cooled transformers, many smaller type H transformers for general illumination, as well as constant current transformers for the series-arc lighting system, which will be used for police illumination. At the sub-station also are motor-generator sets to provide direct current for the operation of searchlights and small motors where they may be installed by exhibitors.

The switchboard for controlling the various circuits throughout the exposition grounds is located in a gallery and is typical of modern switchboard engineering. All the electrical machinery follows standard lines similar to that installed at the St. Louis, the Pan-American and other American expositions.

Those who have seen the plans of the Jamestown Exposition predict that the electrical features, particularly the illumination, will equal, if not excel, the display at the famous Pan-American Exposition. Thousands of Edison lamps will be supplemented by search-lights both on land and on the fleets anchored in Hampton Roads, combining to make the nightly pageant magnificent and beautiful.

Works Pyrometer.

When pyrometers were first transferred from the laboratories to the works they were used in the same forms, exactly, as when in the laboatories, yet they received quite different treatment and were desired for somewhat different use. One step after another has been made to make the works instruments suitable to industrial requirements.

By far the majority of high temperature processes employ temperatures between 200° and 1,000° C. and it is fortunate that thermocouples of certain metals and alloys give us stable and comparatively heavy currents within that range. By keeping down the resistance of the thermocouple, the lead and the measuring instrument, sufficient current is obtained to move the system of a double pivoted galvanometer. This means a portable or wall pattern galvanometer that can be handled as one would handle a voltmeter or ammeter, that is not affected by vibrations, and that is not expensive.

Hand in hand with the robust galvanometer comes the non-fragile portion of the pyrometer that is to go into the furnace. Either two thermocouple elements, in the form of heavy rods or one in the form of an outer tube and the other a rod inside and insulated from it make up the furnace piece. Retaining each and all of these improvements in the works pyrometer the new pyrometer, just being put out by the Wilson Maeulen Co., 110 Liberty St., New York City, has the great added advantage of being easy to read.

A glance at the indicator (Fig. 1) shows the general appearance of it, but to realize how easy it is to read this instrument at a distance from it it must be borne in mind that the dial is 10 inches across. The scale is actually 7¾ inches long and graduations so large that it can easily be read 12 feet away. And this is a real advantage and not only an apparent one, for we all know how much oftener things that are easy to do are done than are those which are not. When the men in the works have a great big finger continually pointing at the temperature they are forced to see and respect it. It practically forces itself upon them. When a man has to leave his work and go over and squint at an indicator he will do it just as seldom as he thinks he may. When it is so big that he can read it 12 feet away he feels that he has something to help him, not that it is an intruder that is brought in to take up his time, introduce complications and give him trouble to use.

In this pyrometer the thermocouple is in the form of a pure iron tube as one element of the couple, the other element being a rod of special alloy which passes down through the tube,

FIG. 1.—INDICATOR OF WORKS PYROMETER.

being insulated from it at all points. The tube is closed at one end and at that point the tube and rod are electrically welded.

This thermocouple makes a particularly strong fire-rod which stands an enormous amount of abuse for the reason that the insulation separating the two elements is inside the tube forming one element and so is not subjected to abrasion. In most cases the fire rod needs no auxiliary protection, and so being exposed directly to the heat quickly assumes the surrounding temperature, causing the indicator to respond quickly to temperature changes.

The highly polished brass case with beveled plate glass front make this an exceedingly attractive instrument. The pivoting of the moving coil in jewel bearings insures lasting sensitiveness, a requisite for continued accuracy.

Notes.

Porcelain-Lined Apparatus.—Stuart & Peterson, of Burlington, N. J., have sent us their bulletins describing "Hercules" steam-jacketed kettles which they manufacture in sizes from 5 gallons capacity up to 450 gallons capacity. These kettles are also manufactured with porcelain lining in capacities ranging up to 110 gallons. If desired these kettles are provided with safety valves.

Insulator Clamps.—We have received from the Clark Electric & Manufacturing Co., of 135 Broadway, New York, several of their bulletins describing a number of types of clamps for use in connection with high tension and cable insulators. Several types of these clamps are designed to hold firmly the transmission cable as it passes over the large petticoat insulators used in long transmission work. The bulletins also describe the copper splicing sleeves manufactured by this company for splicing hard-drawn copper wires and cables. These sleeves consist of seamless copper tubes, oval in shape, and slightly tapered at each end. The ends of the cable to be spliced are slipped into the tube from its opposite ends and the splice made secure by twisting the splice from both ends.

Electrolytic Assaying.—Electrolytic processes and appa

ratus are proving very successful and time-saving in the assay office and ore-testing works of Mr. Chas. M. Fassett, of Spokane, Wash. A motor generator, supplied with current from the lighting circuit of the city, furnishes 10-volt current for electrolytic analysis. To further reduce the voltage rheostats are provided. The modern methods by means of which it has become possible to greatly reduce the time of electrolytic analysis and which are essentially based on thorough circulation of the electrolyte, are applied. An electrolytic analysis of copper now takes 2 hours.

Calcium Cyanamide.—Before the Washington Section of the American Chemical Society, Dr. A. Frank, Jr., of Berlin, delivered a lecture, on April 1, on the manufacture and uses of calcium cyanamide (kalkstickstoff or, verbally translated, lime-nitrogen). The process is the invention of the speaker's distinguished father, Dr. A. Frank, of Charlottenburg, and Dr. N. Caro, and has been repeatedly discussed at length in our columns (see, for instance, page 77 of our March issue). Dr. Frank stated that calcium cyanamide has been produced on a commercial scale in German and Italian works for three years, and the Italian works (which were illustrated in our Vol. IV., p. 328) are now quadrupling their capacity, and in addition thereto European works are in process of construction whose initial capacity will be in the neighborhood of 50,000 tons per year. The American Cyanamid Co., of 100 Broadway, New York City, have procured the rights of the operation of the process in the United States, and are preparing for its manufacture in this country on a large scale.

The Crocker-Wheeler Co's branch managers' annual convention was recently held, and it was announced that the company had done more business during 1900 than in any other year since its foundation eighteen years ago. Among the specialties that have brought special success to the company during the past year are the W type of rolling-mill motors, direct-current motors for machine tools, etc., and alternating-current generators of large capacity. The construction of alternating current machinery by the Crocker Wheeler Co. is based on the designs of Brown, Boveri & Co., of Switzerland. An instance of the recognition which they have found is the installation by the California Gas & Electric Corporation, of three 4,000-kilovolt-ampere Crocker-Wheeler alternators for operation in parallel. These are the largest alternators ever built for gas-engine drive and for operation in parallel. Some interesting data on the company's alternating-current machinery with illustrations are given in Bulletin 74, entitled Engine Type A. C. Generators.

Multimeter.—The Weston multimeter is a new form of electrical measuring instrument which will quite accurately serve the purposes of a direct-current voltmeter, millivoltmeter, ammeter, mil-ammeter, ohmmeter, ground detector and wheat-stone bridge. It may thus be called a universal instrument of particularly high accuracy. It consists essentially of a Weston-type wheatstone bridge, a battery of twelve silver chloride cells and an indicating instrument with detachable shunts.

Héroult Electric Steel Plant at Remscheid, Germany.—The first Heroult plant at Remscheid (described on page 58 of our February issue) has been in operation nearly a year and is turning out 25 tons of high-grade steel, principally tool steel, every day. This plant was formerly a crucible-steel mill, making tool and saw steel by the old system in pots. As steel can be produced by the Héroult process much more economically and more satisfactory in quality and uniformity, the owners of the plant abandoned the old crucible pot system entirely after the Heroult process had been less than two months in operation. A new Héroult plant is now being constructed in addition to the foregoing, with a capacity of about four times the output of the present mill. Sufficient hammers and rolling mills of modern types to finish this additional product are also in course of construction. According to latest advice the new mill will be ready to start this Fall.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

Calcium Carbid (Continued).

No. 555,796, March 3, 1895, C. Whitehead, of Washington, D. C.

Calcines dolomite, mixes the result, double oxid of calcium and magnesium, with finely-divided carbon, and smelts with an alternating or direct current at 60 volts potential in the electric furnace, consisting of the carbon crucible electrodes set in brickwork and receiving a depending carbon rod electrode. Broken carbon in the bottom of the crucible acts as a conducting pole. The furnace has a tap hole. The described product is a double carbid of magnesium and calcium.

No. 557,057, March 24, 1896, E. N. Dickerson, of New York, N. Y.

Smelts a mixture of finely-divided calcium oxid and carbon by feeding it into an arc between the ends of two horizontal carbon electrodes. These electrodes pass closely through opposed openings in the lower end of the furnace, contact being made by rollers and springs connected with the dynamo. The charge is supported and preheated in a vertical muffle chamber, having a hopper at its upper end and containing a vertical shaft with horizontal stirring arms. Around the muffle and spaced therefrom is an outer wall through which pass blow-pipes fed with gas and air, received from heating coils, for instance, in a stack outlet at the top. The carbon monoxid rising from the zone of reduction into the space around the muffle is burned by air introduced through the blow pipes. The liquefied calcium carbid is tapped out into a car consisting of a series of molds. A flux may be added to the charge to render the carbid more fluid, depending on the distance which it has to flow.

No. 551,461, Dec. 17, 1895, William C. Clarke, of New York, N. Y.

Employs a furnace in which the electrodes are placed horizontally so that the hot gases set free will pass directly away. The charge of pulverized coke or coal twelve parts, and unslacked lime twenty parts, finely pulverized and mixed, surrounds the electrodes and nearly fills the furnace, which may have a loose perforated cover, which, however, is unnecessary. In operation the electrodes are first brought together, or nearly together, and then gradually separated, a mass of calcium carbid accumulating between them. When the ends of the electrodes nearly reach the walls of the furnace, the current is shut off, the electrodes drawn away from the carbid and the carbid, with an adherent shell of carbon and lime is removed by hooks or grappling tongs. The shell protects the carbid from the moisture of the atmosphere. The hot material remaining in the furnace falls into place between the electrodes, which are again brought together, current being turned on, fresh charge mixture added and the operation repeated. One of the electrodes may be fixed and the other movable.

No. 552,036, Dec. 24, 1895, Ludwig K. Böhm, of New York, N. Y.

A filament for incandescent electric lamps, consisting of a carbid of calcium or other metal. The filament is made from a mixture of a metallic oxid, for example, one of barium, strontium, calcium, magnesium or iron, and carbon and is then heated to incandescence by an electric current. Carbon may be added in excess of that required for the production of the carbid, the filament then consisting of a mixture of the carbid and carbon. The carbid filament, while sufficiently conductive, has the advantage of higher specific resistance than pure carbon.

(*To be Continued.*)

NEW BOOKS.

Transactions of the American Electrochemical Society. Vol. X. Tenth General Meeting, New York, Oct. 8 and 9, 1906. 132 pages. Illustrated. Bound in cloth. Price, $3.00 net. To colleges, libraries, technical societies and journals, $2.00 net. Philadelphia: The American Electrochemical Society.

German Monographs on Applied Electrochemistry. Vol. XXV. *Deutsches Patentrecht für Chemiker.* By Dr. Julius Ephraim. 608 pages. Paper cover. Price 18 marks (retail price in New York, $6.00). Halle a. S.; Wilhelm Knapp.

A Textbook of Electrochemistry. By Max Julius L. Le Blanc. Translated from the fourth enlarged German edition by Willis R. Whitney and J. W. Brown. 338 pages. Illustrated by tables and diagrams. Bound in cloth. Price, $2.60 net. New York: The Macmillan Co.

Technische Anwendungen der Physikalischen Chemie. By Dr Kurt Arndt. 304 pages, 55 illustrations. Paper binding. Price, 7 marks (retail price in New York, $2.35). Berlin: Mayer & Muller.

The Elements of Chemical Engineering. By J. Grossman. Illustrated. Bound in cloth. Price, $1.50 net. Philadelphia: J. B. Lippincott Co.

Elementary Chemistry. By Sir Enfield H. Roscoe. Revised and enlarged by L. Elliott Brookes. 276 pages. Illustrated. Bound in cloth. Price, $1.00. Chicago, Ill.: Frederick J. Drake & Co.

Principles of Copper Smelting. By Edward Dyer Peters. 612 pages. Bound in cloth. Price, $5.00. New York: Hill Publishing Co.

Hydrometallurgy of Silver. With special reference to chloridizing roasting of silver ores and the extraction of silver by hyposulphite and cyanide solutions. By Ottokar Hofmann. 345 pages, 83 illustrations. Bound in cloth. Price, $4.00. New York: Hill Publishing Co

A Textbook of Mining Geology. By James Park. Illustrated. Bound in cloth. Price, $2.00 net Philadelphia, Pa.: J. B. Lippincott Co.

The American Steel Worker. A twenty-four years' experience in the selection, annealing, working, hardening and tempering of various kinds and grades of steel. By Russell E. Markham. Second edition. 370 pages, illustrated with diagrams. Bound in cloth. Price, $2.50. New York: Derry-Collard Co.

Cement and Concrete. By Louis Carlton Sabin. 683 pages, 161 tables of tests. Illustrated Cloth binding. Price, $5.00 net. New York: McGraw Publishing Co.

The Laboratory Book of Mineral Oil. By J. A. Hicks. Illustrated. Bound in cloth. Price, $1.00 net. Philadelphia: J. B. Lippincott Co.

Long Distance Electric Power Transmission. A treatise on the hydro-electric generation of energy, its transformation, transmission and distribution. By Rollin W. Hutchinson, Jr. 345 pages. Illustrated. Bound in cloth. Price, $3.00. New York: D. Van Nostrand Co.

Peabody Atlas. Shipping lines and coal railroads in the central commercial district of the United States, accompanied by chemical, geological and engineering data By A Bement 149 pages. Illustrated. Bound in cloth Price, $5.00 Chicago, Peabody Coal Co

Questions and Answers from the Gas Engine 274 pages $1.50. Cincinnati: Gas Engine Publishing Co.

Technological and Scientific Dictionary. By G F Goodchild and C F Tweney. 874 pages. Illustrated Bound in half morocco. Price, $6.00 net. Philadelphia, Pa. J B Lippincott Co.

A Pocket Dictionary of Technical and Scientific Terms. 128 pages. Leather binding Price, 50 cents. New York E. P. Dutton & Co.

BOOK REVIEWS.

The Principles of Copper Smelting By Edward D. Peters Professor of Metallurgy, Harvard University. Large 8vo.; pp. viii — 610 Price, $5.00. Hill Publishing Co., New York, 1907

The 15,000 copies of *Modern Copper Smelting*, by Dr Peters, which have been read with instruction and pleasure by metallurgists everywhere, will have prepared a cordial reception for this supplementary volume on "reasons why," which is no less a masterpiece than its predecessor The earlier book lays the foundation for the later one; it described apparatus, furnaces, machinery, and explained the construction and use of all the *metallurgical equipment* of a copper plant, while this deals with the chemical and physical principles involved in the operations or utilized by the apparatus, the reasons why things are done or are practicable in one way and not in another, in other words, it furnishes and co-ordinates the *mental equipment* of the copper metallurgist.

The above being stated, the nature of the book under review will be easily understood. It is didactic throughout, frequently conversational, a heart to heart talk of master to pupil. There is hardly anything to match it in modern scientific literature except Ostwald's now famous *Conversations on Chemistry*. The chapter on first principles of smelting is so clear that almost any 10-year-old boy could grasp them; the principles of roasting, chemistry of smelting, practical study of slags, description of matte, production of blister copper, refining of copper are without exception handled in the same happy style Prof. J. W. Richards has written for this work a 25-page chapter on the thermochemistry of copper metallurgy, illustrated by several problems worked out in detail, showing how the heat is developed in copper furnaces and where it goes to.

On the practical side, there are given brief descriptions of the various furnaces and apparatus used, such as was necessary to form the basis for a discussion of the different principles utilized by the various types. Particularly important is the 125-page chapter on pyritic smelting, for the writing of which Dr. Peters possessed a *congeric* of qualifications which no one else anywhere could match This chapter alone is a splendid contribution to the present metallurgical literature of copper.

At such a banquet, it is hypocritical to criticise minute shortcomings when there is not a single large one to point to. Still, being invited to such criticism by the author, we will point to a few differences of opinion.

We think that chemical calculations, such as are explained on page 55 and exist all through the book, are much better understood by practical man or student, if based simply on the numbers representing the atomic and molecular weights involved, and not reduced to decimal factors. We would prefer to pass from the weight of Fe to that of FeO, for instance, by multiplying by $\frac{72}{56} = \frac{9}{7}$, that is, by multiplying by 9 and dividing by 7, whereas, Dr Peters prefers to multiply by 1.2857, which is $\frac{9}{7}$ run out to four places and the fifth ignored. Curious to relate, Dr Peters remarks that the same result may also be attained *approximately* by using the factor 9/7! In our view, the fraction is simpler and easier; and, of course, it is the decimal factor which does the *approximating*, if any is done at all

In the practical study of slags, we would have preferred to see the *quantivalence* of the acid and basic elements compared, instead of the oxygen ratios A bi silicate is fundamentally a silicate in which the quantivalence (combining power) of the silicon present is twice that of the basic elements present and it is these relative combining powers which constitute the essential nature of the silicate Is it not, therefore, more logical and quite as easy arithmetically, to say that since one molecule

JUST PUBLISHED

12mo, Cloth 498 Pages Price, $2.50 Net

Van Nostrand's
CHEMICAL ANNUAL

A Hand-book of Useful Data
for Analytical, Manufacturing and Investigating Chemists, and Chemical Students

Based on Biedermanns' "Chemiker Kalender"

EDITED BY

Prof. J. C. OLSEN, A.M., Ph. D.

Polytechnic Institute, Brooklyn
Formerly Fellow Johns-Hopkins University
Author of "Quantitative Chemical Analysis, by Gravimetric, Electrolytic, Volumetric and Gasometric Methods."

With the Co-operation of Eminent Chemists

FIRST YEAR OF ISSUE, 1907

The absence of a comprehensive reference book of numerical data of the Science, has induced the publishers to undertake the publication of this Annual, which it is their intention to issue, with new data added, annually.

8vo, Cloth 367 Pages Price, $3.00 net

SOLUBILITIES
OF
Inorganic and Organic Substances

A Hand-book of the most
Reliable Quantitative Solubility Determinations

COMPILED BY

ATHERTON SEIDELL, Ph.D. (J.H.U.)
Bureau of Chemistry, U. S. Department of Agriculture

The principal features which have been emphasized in the preparation of this volume are as follows:

Completeness of Data
Uniformity of Expressing Results
Selection of Most Reliable Determinations
Arrangement of Material

RECENTLY PUBLISHED

8vo, Cloth, Illustrated, 298 pages Price, $3.00 net

EXPERIMENTAL
Electrochemistry
Theoretically and Experimentally Treated

BY

N. MONROE HOPKINS, M.Sc., Ph.D.,
Assistant Professor of Chemistry in the George Washington University, Washington, D. C.

Profusely Illustrated with 130 New Drawings, Diagrams and Photographs, accompanied by a Bibliography.

D. VAN NOSTRAND COMPANY
Publishers and Booksellers
23 Murray and 27 Warren Sts., New York

of SiO_2 weighs 60, and contains one atom weight of Si whose quantivalence is 4, that, therefore, the combining power of the silicon in any weight of silica is represented by 4/60 of the weight of the silica?

Similarly, the combining power of the

Aluminium in any weight of $Al_2O_3 = 6/102 \times$ weight of Al^2O^3.

Calcium in any weight of $CaO = 2/50 \times$ weight of CaO.

Magnesium in any weight of $MgO = 2/40 \times$ weight of MgO.

Iron in any weight of $FeO = 2/72 \times$ weight of FeO.

And thus the real things themselves, the relative combining powers of the elements present, can be compared. We plead for this way of teaching silicate ratios, because it is more fundamental, more logical and not a whit more complicated arithmetically.

The metallurgical fraternity of America has surely put an extra feather into its cap by this achievement of our genial Dr. Peters.

* * *

The Proceedings of the Chemical, Metallurgical and Mining Society of South Africa. Vol. III. May, 1902–June, 1903. Illustrated. 483 pages. Price, $6.00. Johannesburg, Transvaal: The Society.

The second volume of the proceedings was reviewed on page 75 of our Vol. II., and since that time we have had very often occasion to call attention to the high value which the work of this Transvaal society must have for anybody interested in the metallurgy of gold.

The issue of the third volume had been delayed by the Boer war; the manuscripts had gone astray and had to be collected again with much trouble. We have further to acknowledge a delay of this review, which could not be avoided on account of lack of space. Even at this late date a brief summary should now be welcome. It is to be hoped that the Society will be able in future to bring out more promptly the volumes of their proceedings.

The main part of the volume (372 pages) contains the following papers with discussions:

Notes on the analysis of cyanide solutions, by Andrew F. Crosse. Notes on the treatment of slimes by means of filter presses, by Clement Dixon. The smelting and refining of zinc-gold slimes, by E. H. Johnson and W. A. Caldecott. A slight improvement in extractor boxes, by S. B. Hutt. An improved washbottle for quantitative work, by E. H. Weiskopf. Residual products of the dynamite factory and their value to the gold industry, by W. Cullen. The thermo-hyperphoric process, by A. T. Firth. Notes on valuing a gold mine, by T. Lane Carter. Notes and queries, by H. T. Durant. The lead smelting of zinc-gold slimes, by P. S. Tavener. Notes on mine sampling of the main reef series, by D. J. Williams. The economic use of petroleum oil gas furnaces, as applied to smelting, laboratory work and drill heating, by David Laird. The theory of miss-fires and some conclusions of practical value, by E. H. Weiskopf. Notes on commercial cyanide of potash, by A. Whitby. Some notes and suggestions on miners' phthisis, by W. Cullen. The regeneration of working cyanide solutions where zinc precipitation is used, by Andrew F. Crosse. Notes on the common practice of quartz milling on the Rand, by Fraser Alexander. Extraction of gold from cyanide house slimes by a wet method, by John Fleming. An automatic sampler for tailings, sands and slimes, by C. H. Pead. The refining of lead bullion (by the Parkes process), by F. L. Piddington. A few remarks on banket formation, by A. R. Sawyer.

An appendix of about 100 pages contains the minutes of the proceedings at the monthly meetings, reports, correspondence, notes, abstracts and a good index.

A complete set of the proceedings of this Society should be in the library of anybody interested in the cyanide process and in the metallurgy of gold in general.

Production of Aluminium and its Industrial Use. By Adolphe Minet. Translated by Leonard Waldo, S. D 8mo. 250 pages. $2.50. John Wiley & Sons, New York.

The German edition has already been reviewed in this journal (December, 1902, p. 147). The present book is a translation, with the addition of a chapter by Minet, in which he tries to make an answer to the criticism which his work received from a German electrometallurgist, and another chapter by the translator, in which an endeavor is made to supply the glaring deficiency in the book respecting the production of aluminium in America.

The work contains six *lines* on the subject of the occurrence of aluminium in nature, within which compass are two mistakes, one in the composition of the most abundant ore of aluminium. Further on, the process in which Americans are the most interested, that of Chas. M. Hall, by which all the pure aluminium at present made in America is manufactured, is described in thirty-seven lines, with a reproduction of the patent drawings made in 1886—although commercial details of the present method of working have been published for ten years, even accompanied by photographs of the Hall apparatus in actual use. There are 34 pages devoted to Minet's own processes, which possess a certain historic interest but are nowhere at present being used, or at all likely to be.

The chief value of the book lies undoubtedly in the fact that it is the only book on aluminium which stands for a theory, accepted by such an authority on aluminium as Dr. Heroult. Undoubtedly, Dr. Waldo, who has also paid much attention to the electrolytic manufacture of aluminium, also believes in the same theory. For otherwise there would be no real excuse for the English edition. But it should be pointed out that the majority of the specialists on the theory of aluminium, among them Prof. Richards and Prof. Haber, are strong opponents of this theory. Whatever may be the truth, as long as there is any uncertainty on the subject, Mr. Minet had a right to define his theoretical standpoint clearly in this monograph.

We are sorry to have to state frankly that the translation is by no means satisfactory. To anybody who reads the translation and who knows the high accomplishments of the gentleman who is named as translator on the title page, it will at once be evident that he cannot have prepared the translation himself. He should have taken more care, however, in revising it, since he will be held responsible by the reader.

In many places the blunders in translation make the English quite unintelligible. Caustic soda is called several times "caustic hydrate of soda;" on page 2, "Thonerde" is translated "clay," instead of "alumina;" "rothglut" and "weissglut" are translated by the awkward expressions "red-glow" and "white-glow," instead of "red-heat" and "white-heat;" on page 7, *entwässer* (dehydrated) is translated *dephlegmated*—an alchemistic term for rectifying spirits; an *amalgamated* zinc plate is called an *amalgamation* of zinc plate; electrolytic *coatings* are called *incrustations* (page 60); using platinum electrodes *and* great current densities is translated platinum electrodes *of* great current densities; a *current* of 3,000 amps. is called a *stream* of 3,000 amps.; on page 21, *Wechselstrom* is translated direct current and *Gleichstrom* alternating current, just reversing the sense of the statement; *zersetzen* (to decompose) is in many places translated *dissolve*, thus completely obscuring the meaning (pages 65, 66, 68, 69, etc.); *Treibprozess* (a cupellation of scorifying operation) is translated *tempering*, and set forth as a means of separating aluminium from zinc alloys (!) (page 69); *zerkleinert* (broken up small) is made incomprehensible by being translated *diminished* (page 54). A praiseworthy effort to correct a mistake in the original was made on pages 85 and 86, where the original erroneously spoke of the *chlorine* (instead of the *fluorine*) coming from aluminium *fluoride*, and gave the proper reaction for the fluoride; but the translator remedied the matter by speaking of the chlorine coming from the chloride, and yet retained the proper reaction in which only the *fluoride* was concerned.

JUST READY

"FOODS AND THEIR ADULTERATIONS"

The Origin, Manufacture and Compositon of Food Products, Description of Common Adulterations, Food Standards and National Food Laws and Regulations

By HARVEY W. WILEY, M. D.

Chief Chemist U. S. Department of Agriculture, Washington, D. C.

Octavo: 600 pages

11 Colored Plates and 80 Other Illustrations

Cloth, $4.00 net

Synopsis of Contents: Introduction.—Meats.—Poultry and Game Birds.—Fish Foods.—Milk and Milk Products.—Cereal Foods.—Invalid and Infant Foods. Vegetables, Fruits, Spices, Nuts, Etc.—Sugar and Honey.—Food Standards, Rules and Regulations for Enforcing the Food and Drugs Act.—Regulations Governing Meat Inspection.—Index.

Orders may be sent to any bookseller; or upon receipt of price we will forward to any address, postage or express charges prepaid.

P. Blakiston's Son & Co.

SCIENTIFIC PUBLISHERS

1012 Walnut St., Philadelphia

Handbook of Mathematics

FOR ENGINEERS AND ENGINEERING STUDENTS

By J. CLAUDEL

Translated and Edited from the Seventh French Edition by OTIS ALLEN KENYON

A complete book on Mathematics
It covers very thoroughly
Every branch from Arithmetic to Calculus

TABLE OF CONTENTS

Part I.—Arithmetic. I.—Fundamental Operations on Whole Numbers. II.—Properties of Whole Divisors. III.—Fractions and Decimal Numbers. IV.—Powers and Roots. V.—Ratios. Proportions. Progressions. VI.—Diverse Rules. VII.—Logarithms. Part II.—Algebra. I.—Of the Four Fundamental Algebraic Operations. II.—Equations of the First Degree. III.—Powers and Roots of the Algebraic Quantities. IV.—Equations of the Second Degree. Part III.—Geometry. Plane Geometry. Solid Geometry. Problems in Geometry. Part IV.—Trigonometry.—Plane. Spherical Trigonometry. Part V.—Analytical Geometry. Part VI.—Calculus. I.—Differential Calculus. II.—Integral Calculus. III.—Applications of Integral Calculus.

Cloth, 708 Pages. 422 Illustrations. Price, $3.50 Net.

Sent anywhere postpaid for the price

Send Us Your Inquiries Write For Our Catalogs

McGraw Publishing Company

PUBLISHERS, IMPORTERS AND BOOKSELLERS

114 Liberty Street, New York

LOW—*Technical Methods of Ore Analysis.* By Albert H. Low, B.S. 8vo, 2d edition, xii + 277 pages, 14 figures. Cloth, $3.00.

CONTENTS Apparatus, Electrolysis, Logarithms, Aluminum, Antimony, Arsenic Barium, Bismuth, Cadmium, Calcium, Chlorine, Chromium, Copper, Iron, Lead, Magnesium, Manganese, Mercury, Molybdenum, Nickel and Cobalt, Phosphorus, Potassium and Sodium, Silica, Sulphur, Tin, Titanium, Tungsten, Uranium and Vanadium, Zinc, Combining Determinations, Boiler Water, Coal and Coke, Testing Crude Petroleum, Tables, Appendix, Index.

MINET-WALDO—*The Production of Aluminum and its Industrial Use.* By Adolphe Minet, Translated, with additions, by Leonard Waldo, S.D. (Harv.). 12mo, vi + 266 pages, 57 figures. Cloth, $2.50.

CONTENTS Part I Processes for the Production of Aluminum; Chemical Methods of Producing Aluminum. Electrochemical Methods of Producing Aluminum Part II Aluminum and its Alloys, Methods of Working and Uses; The Aluminum Industry, Aluminum and its Alloys; Working of Aluminum, Uses of Aluminum, Appendix—Supplementary Notes by Adolphe Minet; Industrial Questions; The Theoretical Part. Aluminum in the United States; Supplementary Note by the Translator.

WELLS—*A Text-book of Chemical Arithmetic.* By Horace L. Wells, M.A. 12mo, vii + 166 pages. Cloth, $1.25.

OSTWALD—*Conversations on Chemistry.* IN TWO PARTS.

Part I. General Chemistry. Authorized Translation by Elizabeth Catherine Ramsay 12mo, viii + 250 pages, 46 figures. Cloth, $1.50.
Part II. The Chemistry of the Most Important Elements and Compounds. Authorized Translation by Stuart K. Turnbull. 12mo, viii + 373 pages, 32 figures. Cloth, $2.00.

JOHN WILEY & SONS
43 & 45 E. 19th St., New York City

Eleventh Edition

Metallurgy of Cast Iron

A complete exposition of the processes involved in its treatment, chemically and physically, from the blast furnace through the foundry to the testing machine, being a practical compilation of original research.

By THOMAS D. WEST

Contents

PART I.—Manufacture and Use of Coke—Properties in Ores—Operations of Blast Furnaces—The Different Brands of Pig-Iron and How to Purchase and Use Them Intelligently (27 chapters). II.—Elements in Cast-Iron and Their Physical Effect—Utility of Chemical Analyses and How to Use Them in Making the Different Mixtures of Irons Used in Making Gray and Chilled Castings (21 chapters). III.—Properties of and Methods for Testing Molten Iron—Phenomena in the Actions of Cooling Metal, etc.—Results of Tests in All Kinds of Irons—Best Methods for Testing (23 chapters). APPENDIX. Selected Tables for Use in Furnace and Foundry Work.

Cloth 638 Pages 153 Illustrations Price, $3.00 net

Sent Anywhere, postpaid, for the Price by the

McGRAW PUBLISHING COMPANY

114 Liberty Street :: New York

Electrochemistry—I. Theoretical Electrochemistry and Its Physico-Chemical Foundations. By Dr. Heinrich Danneel, Privatdozent at the Institute of Technology of Aachen. Translated from the German by Dr. Edmund S. Merriam, associate professor in Marietta College, Ohio. 181 pages, 18 illustrations. Price, $1.25 net. New York: John Wiley & Sons.

The original German book appeared in the *Sammlung Goeschen*—a collection of text books of small size and exceeding low price. Both size and price have naturally been somewhat increased in the American edition, without, however, diminishing in the least its usefulness as a very handy pocket-book for students.

The information given is clear, concise and to the point. A very large amount of material has been condensed into the small space at disposal.

Chapter I. deals with "work, current and voltage," on the basis of thermodynamics, with applications to gases and solutions. Chapter II. discusses "the chemical equilibrium, statics and kinetics," and gives the law of mass action and "van't Hoff's equation."

Then passing over to electrochemistry proper, the author deals in Chapter III. with the "theory of electrolytic dissociation," and in Chapter IV. with "conductivity," with a full explanation of the migration of ions. Chapter V. deals with "electromotive force and the galvanic current," giving the Gibbs-Helmholtz formula and van't Hoff's equation, Nernst's theory of concentration cells, etc. The sixth chapter is devoted to a discussion of "polarization and electrolysis," and gives Faraday's law. Chapter VII. is a brief exposé of the electron theory.

The summary given above hardly does justice to the enormous amount of information gathered together in this book; and what is more, this information is not only qualitative but quantitative, great care having evidently been taken to give the most reliable figures for the physical and chemical constants. The information is therefore given in the book ready for use.

Dr. Merriam has made a remarkably good translation. The book is one of the best translated books which have ever come into the reviewer's hands out of the great number of German chemical books which have been translated into English.

* * *

The Recent Development of Physical Science. By William Cecil Dampier Whetham, M. A., F. R. S., Fellow of Trinity College, Cambridge. 344 pages, 5 portraits, 39 illustrations. Price, bound in cloth, $2.00 net. Philadelphia, Pa.: P. Blakiston's Son & Co.

In the development of modern physical science there have been manifest two leading tendencies, or we may say with Wagner "leitmotive." One is the tendency towards broadest generalization on broad thermodynamical basis, without employing any molecular or atomic hypotheses. The other is the bold attempt to erect a detailed theory of matter upon the electronic hypothesis.

From the work done along both these lines of endeavor, this book brings selected chapters. While the presentation of the subject is throughout excellent, the chapters on electrons are specially well written. Undoubtedly the author was inspired by the genius loci-Cambridge.

The book contains eight chapters: on the philosophical basis of physical science; the liquefaction of gases and the absolute zero of temperature; fusion and solidification; the problems of solution (both aqueous solutions and solid solutions being considered); the conduction of electricity through gases; radio-activity; atoms and æther; astro-physics. The book brings fine portraits of Newton, Kelvin, Gibbs, van't Hoff and J. J. Thomson.

The book is extremely well written and should appeal to all professional men who wish to become acquainted to a certain degree with some of the most important of these much-talked-of and little-understood new developments of physical science.

Electrochemical and Metallurgical Industry

VOL. V. NEW YORK, JUNE, 1907. No. 6.

Electrochemical and Metallurgical Industry

With which is Incorporated Iron and Steel Magazine

Published on the first of each month by the
ELECTROCHEMICAL PUBLISHING COMPANY,
[Incorporated.]
114-118 LIBERTY STREET, NEW YORK.

J. W. RICHARDS, PH. D. ..... *President*
E. F. ROEBER, PH. D. ..... *Editor*

Subscription Price: $2 per year, postpaid to any part of the world. Single copies 25 cents.

Copyrighted, 1907, by the Electrochemical Publishing Co.

Entered as Second-Class Matter, June, 1903, at the Post-Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, JUNE, 1907.

CONTENTS.

EDITORIAL 203
Philadelphia Meeting of the American Electrochemical Society.. 203
Some Aspects of Sodium Chloride Electrolysis 204
Concerning Rail Metal 205
Iron and Steel Institute 206
The Iron and Steel Market 206

CORRESPONDENCE:
The Electric Furnace in the Foundry. By Richard Moldenke 207
The Breakage of Steel Rails 207
The New Electrolytic Alkali Works in Niagara. By L. Backeland ... 209
Metallurgical Calculations (Copper). By J. W. Richards 212
American Foundrymen's Convention 216
Report of Philadelphia Meeting of the American Electrochemical Society 217

NOTES ON ELECTROCHEMISTRY AND METALLURGY IN GREAT BRITAIN 234

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS 237

RECENT METALLURGICAL PATENTS 241

SYNOPSIS OF CURRENT PERIODICAL LITERATURE 242

American Museum of Security 244
A Modern Electrically Operated Copper Converter. By G. B. Shipley 244
Long-Scale Switchboard Instruments 246
A Non-Stop Run 247

NOTES 248

DIGEST OF UNITED STATES PATENTS 248

NEW BOOKS 249

BOOK REVIEWS:
Ottokar Hofman on Hydrometallurgy of Silver 249
E. W. Buskett on Fire Assaying 249
F. W. Roller on Electric and Magnetic Measurements and Measuring Instruments 250
J. H. Long's Textbook of Elementary Analytical Chemistry 250
E. Haanel's Report on Electric Smelting Experimtnts at Sault Ste Marie 250
B. Neumann on Electrometallurgy of Iron 251
J. Ephraim's Deutsches Patentrecht für Chemiker 252
Pfanhauser-Richards on the Manufacture of Metallic Articles Electrolytically—Electro-Engraving 252
Wellcome's Photographic Exposure Record and Diary, 1907 252

Philadelphia Meeting of the American Electrochemical Society.

After five years the American Electrochemical Society came back to its birthplace, Philadelphia, for the annual convention of 1907. Five years ago the leading electrical engineering journal of this country commented on the Society's inaugural meeting as having been "of such a high order of merit that to keep future meetings up to the standard there set may become a difficult task." This prophecy has come true. But difficulties never prevent success when there is an earnest will to attain it. In spite of the ups and downs which are natural in any case, the course of the American Electrochemical Society has been in the main decidedly an upward course. The Society has undoubtedly done useful work; it has fulfilled the purpose for which it was founded, "the advancement of the theory and practice of electrochemistry." Through the personal intercourse of members at the meetings theorists and practical men have learned to understand each other better, and a sound professional solidarity of all workers in the field of electrochemistry has been produced. Through its *Transactions* the Society has strongly and successfully appealed to its whole membership and even to a much greater circle of readers. In spite of their intrinsic value there is, however, a decided possibility of improving the *Transactions* by extending the discussions of the papers. A stricter censorship from an appointed committee is a doubtful remedy. More thorough critical discussion from the membership at large is a far better thing. But this cannot be obtained unless all papers are printed well in advance and distributed. If then the rule is established (as at the last convention of the Iron and Steel Institute) to allow any author not more than ten minutes to summarize his paper, there will be time for a good discussion—friendly and otherwise, orally and communicated—and the *Transactions* will greatly gain in interest.

* * *

The meeting in New York last Autumn had been a frost, due to a series of unfortunate circumstances which prevented early and proper arrangements and announcements. The meeting in Philadelphia last month was a splendid success. It showed decidedly that the Society is still young and healthy and strong. The program was well balanced in all its features. Undoubtedly there were too many papers on the program for proper presentation and discussion, but this will be no disadvantage for the *Transactions*. Several illustrated lectures on broad subjects, by Dr. E. F. Smith on his work in electroanalysis, by Dr. C. P. Steinmetz on electric conduction, and by Prof. A. T. Lincoln on corrosion of brass, proved exceedingly interesting, and the policy of inviting such lectures should be continued. A great number of highly instructive excursions and visits had been arranged for the afternoons, and as to the purely social features the Philadelphia meeting was certainly as enjoyable as any meeting ever held by the Society, in the sense of the old and sound maxim of Goethe, "Tages Arbeit, Abends Gäste, saure Wochen, frohe Feste."

In view of this success of the meeting, which indicates that the Society has entered into a new era of usefulness, surprise has been expressed in many quarters at the serious discussion of a proposition which threatens the very independence of the Society. It has been made to the American Electrochemical Society by the American Chemical Society. It is proposed that all papers on physical chemistry and electrochemistry read before either Society should be published in one monthly journal under supervision of a joint board. The advantages are evident. The members will receive more for their money. Further, the relative expense of publication will be reduced. In fact were a scientific or engineering society to be run as a commercial enterprise, all the advantages of modern industrial trusts could be urged for such a combination. However, there are complications. Even those who are in favor of the plan do not agree as to how it should be carried out. Mr. Hering has suggested an elaborate but just system of distributing expenses. The other side proposes the Electrochemical Society should pay a flat sum for each member to the Chemical Society. The first proposition was $3 per head. This has now been reduced to $2. In view of this change one wonders how long such an agreement would last. Further, a joint publication board of six is proposed, three from each society, and an editor. Evidently the editor would have the decisive vote. It is impossible to see how to combine this with Mr. Hering's stipulation that the Electrochemical Society should not subject its papers to the censorship of another Society. The *Transactions* are the Society's chief asset from which it derives its standing and individuality. However the above proposition may be carried out the continuity of the *Transactions* will be lost. The necessary consequence will be the loss of identity of the Society itself, which will become the electrochemical section of the American Chemical Society. Those who have worked most enthusiastically for the Society will hardly like this consequence. The Electrochemical Society has come into existence because differentiation and specialization are the keynote of all modern progress in science and engineering. It would not be wise for the Society to take a step now which it cannot take back should it ever desire so. But we have not the slightest doubt that should the question ever come before the members for a mail vote, the Society will be saved by the esprit de corps which it has inspired in the rank and file.

Some Aspects of Sodium Chloride Electrolysis.

An electrochemical reaction cannot be fully understood if looked upon from the standpoint of pure chemistry. Electrochemistry is essentially physical chemistry. Starting with the same chemical reagents it is possible to obtain quite different products by changing the electrical and, in general, the physical conditions of the operation. The classical example from electric furnace practice is the reaction between silica and carbon which has resulted in building up the industries of carborundum, siloxicon, artificial graphite and metallic silicon. An equally instructive example from the field of electrolysis is the decomposition of sodium chloride by the electric current. Starting with the same materials we obtain in cells of different construction chlorate or hypochlorite or chlorine and caustic soda. The conditions for the production of the latter are intrinsically different from the other two cases in so far as it is of fundamental importance to keep the produced chlorine and caustic soda separate from each other so as to prevent any reaction between them. For the purpose of electro-analysis, Dr. Edgar F. Smith has devised an ingenious method of absorbing the chlorine by means of silver anodes and the sodium by means of the mercury cathode. On a large commercial scale where the object is to produce caustic soda and chlorine in ton quantities the absorption of the chlorine has never been attempted while the use of the mercury cathode in the Castner-Kellner cell has assumed immense industrial importance. The Acker process of electrolyzing fused sodium chloride and alloying the sodium with a fused lead cathode is in principle absolutely analogous to the mercury cathode process.

* * *

If the sodium set free at the cathode is not carried out of the sphere of action, but remains in solution in form of caustic soda the electrochemical system is changed. We have at the cathode no longer sodium chloride but a mixture of sodium chloride with sodium hydroxide, so that not only chlorine ions but also hydroxyl ions are migrating from the cathode to the anode. To prevent the hydroxyl ions from reaching the anode and causing trouble there, is the problem of the Glocken process, or gravity process, and of the different types of diaphragm cells. The theory of the Glocken process had formerly been based on the pretty assumption that the fresh solution which is continually being introduced into the anode compartment flows downwards in the bell with the same speed as that with which the hydroxyl ions tend to move upward toward the anode. That this explanation is wrong has been clearly shown in the interesting article of Dr. Steiner published in our last issue. There the correct explanation is also given. In the case of diaphragm cells the diaphragm had first been relied upon to prevent a mixing of the anolyte and catholyte. While mechanical mixing can thus be avoided, a diaphragm cannot prevent the migration of the hydroxyl ions toward the anode. For this reason further devices have been used in the highly improved diaphragm cells of modern construction; for instance, the electrolyte is forced from the anode compartment into the cathode compartment through the diaphragm so as to counteract to some extent the tendency of the hydroxyl to move in the opposite direction.

* * *

The Townsend cell which has been in successful use for a year in Niagara Falls, as described in the interesting paper by Dr. Baekeland in our present issue, is generally called a diaphragm cell. It is true, it contains a diaphragm, but the effect of this diaphragm is very different from that in the ordinary diaphragm cells. In the latter the diaphragm separates the anolyte from the catholyte, and both the anolyte and the catholyte form the electrolyte. In the Townsend cell the diaphragm separates the sodium chloride solution under electrolysis from inert liquid kerosene; there is no real catholyte. In the ordinary diaphragm cells the caustic soda is in solution in the catholyte, and remains therefore within the sphere of electrolytic action. In the Townsend cell the caustic soda is absorbed in the kerosene and carried off and immediately removed from the sphere of electrochemical action. In this respect the Townsend cell stands really nearer to the mercury cathode cell than to the ordinary diaphragm cell. The hydro-

gen gas which is set free together with the caustic soda, and which in other cells has been troublesome in mixing the electrolyte on account of its stirring effect, is used in a very pretty way in the Townsend cell to produce just the opposite result, namely, to help carrying the caustic soda away from the solution as soon as formed.

Concerning Rail Metal.

Those who are not familiar with the ins and outs of making, selling and buying steel rails are in danger of being led to conclude that the strenuous discussion being carried on in the public prints relative to Bessemer and open-hearth rails, carbon, phosphorus and what not, and the diversion from Northern rail mills to the Southern rail mill of orders of railroads naturally tributary to the Northern mills, involve purely a metallurgical point. They are likely to assume that the steel metallurgist is being called upon to devise ways and means of making better steel rails. While this is true, it is by no means the whole truth. The American rail trade has for a number of years past been managed on the principle of "you tickle me and I'll tickle you." The participants in the game have been all the rail mills (but the one located in Alabama) on one side and all the railroads, which handle large iron and steel freight tonnages on the other side. The railroads which are not so located as to be able to obtain large iron and steel freight tonnages have been interested but increasingly disgusted spectators. The Alabama rail mill has also been an interested spectator, but an increasingly satisfied one.

* * *

It may be doubted whether those responsible for the fuss about rail metal in the newspapers have ever speculated upon the modus operandi by which rail orders, sometimes passing the hundred-thousand-ton mark, are placed. Did they by chance devote some consideration to this question they would probably ratiocinate that the negotiations would be conducted by the engineers of the respective parties, the railroad engineer on the one hand drawing from the large fund of knowledge he is well known to possess as to rail breakage, endurance, etc., and the steel works engineer on the other hand, employing his knowledge of the results in quality of different materials and processes involved in the making of a steel rail. However comforting to one's intelligence as a thinking animal and reassuring to his bodily safety as an occasional or frequent passenger on railroad trains such a reasoning may be, it is erroneous. The bulk of the large rail orders are not so negotiated. The operation is usually conducted by the president of the railroad on the one hand and the chief executive or fiduciary officer of the steel-making interest on the other. Did walls have ears, which for the comfort of these important parties they have not, they would probably be in position to repeat such words as reciprocity, tonnage of freight, freight rates, etc., all quite kindred to the subject of conducting business, but not altogether kindred to the metallurgical question of making good rails. We doubt whether in such negotiations much use has been made of such words as carbon, phosphorus, segregation, cropping, drop tests, etc. These subjects were invented to amuse the engineers on the respective sides and enable them to earn their salaries, so that their consciences would be easy. The placing and filling of rail orders has been, usually, no place for the application of this knowledge. We have referred to the first act, that of placing the orders. The second interesting act, that of making the rails, must be read by title. The third, that of inspection, is believed to have occasionally taken the form of the young man delegated for the purpose by the railroad giving the rail-mill superintendent a good cigar, to invite the needful instruction as to how the inspection should be conducted. The last act comprises the use of the rails, the final scene being where the rail breaks, and then the curtain drops, whereupon the newspapers begin throwing eggs of doubtful antiquity.

* * *

Which act of this drama, involving millions of tons of steel and tens of millions of dollars a year, is it which should invite this shower of missiles? We submit with due deference to the so hasty judgment of a large part of the public that the missiles should have been thrown at the end of the first act, with insistent calls for the appearance at the center of the stage during that act of one who should be the chief dramatis persona—the metallurgist. Then, should the play proceed to the third act, that act should not be allowed to be concluded unless this gentleman were accorded the center of the stage throughout the act. The fourth act would then be much more agreeable to the millions of people personally and bodily involved. It is not alone the direction of this popular thought, now that we are at it, with which we desire to find fault. Its foundation is largely erroneous. One would suppose that to the enormous loss of life by reason of the operation of American railways defective rails are the chief, or at least a very important, contributor. It is not so. The reports of the Inter-State Commerce Commission for the second half of last year show a total number of persons killed of 2,612. Of this number 741 were killed in train accidents, and of these 741 there were only 22 who were killed as a result of "defects in roadway." The statistics of the Commission are not further sub-divided in the quarterly reports, so that it is impossible to state what proportion of these 22 were killed through defective rails. Certainly there are other defects of roadway than those due to defective rails. It is sufficiently instructive to observe that the railroads in six months killed 2,612 persons, but less than 22 in accidents due to defective rails.

* * *

Years ago, if the railroads had insisted upon a lower phosphorus content, liberal cropping of the ingot and proper heat treatment as to finishing, they could have gotten these desiderata in Bessemer rails and the rails would have been sufficiently good. Now it is impossible to get the phosphorus down, because low-phosphorus ores are playing out, and instead of selecting the lower-phosphorus ores for rail making the producers must keep them to mix with higher-phosphorus ores, making steel which is outside, or just inside, the commercial phosphorus limit, according to the diligence of the buyer. The result will be the open-hearth rail, and it would not seem to be visionary to think of a further step—the combination of the open-hearth process with some cheap electric refining and mixing treatment, as outlined in connection with the letter of a correspondent on another page of this issue. But, as we tried to point out, the full improvement of the situation involves commercial as well as metallurgical changes.

Iron and Steel Institute.

The thirty-eighth annual general meeting of the Iron and Steel Institute was held in London on May 9 and 10. In the absence of the retiring president, Mr. R. A. Hadfield, who is at present in the United States, Sir James Kitson opened the meeting. From the report of the Council it appears that on Dec. 31, 1906, the Institute had 2,052 members. After thanks had been voted to the retiring president and Council, Sir James Kitson introduced the new president, Sir Hugh Bell, into office.

The first official function of Sir Hugh Bell was the presentation of the Bessemer gold medal to Mr. J. A. Brinell, of Stockholm. Sir Hugh Bell then presented his presidential address, dealing with the progress made during the past hundred years in the manufacture of iron and steel, and especially with the influence of greater transportation facilities on the industry.

A full report of the papers presented at the meeting will be given in our next issue. All of them elicited quite an animated discussion. This was rendered possible by the new rule, adopted by the Council, to print and distribute copies of papers in advance and allow an author not more than 10 minutes to give a summary of his paper for introduction of the discussion.

The Iron and Steel Market.

A great deal has happened in pig iron since our last report. The modest suggestion in that report that there were "prospects that regular consumers will easily absorb all the available tonnage" in Bessemer and basic pig iron for this year's delivery has been borne out, as all the iron which producers could offer has been taken up, prices have advanced $2 or more per ton, and middlemen are about the only sellers, and then only in small lots. The Southern iron market, which was then "firm at $18.50 for second half," has advanced by jumps to $21.50 for third quarter and $20 for fourth, with $18.50 quoted for first half of next year.

Where this will all end is a subject of anxious thought for producer and consumer alike. It is improbable that any drop can come within the next three months, as production invariably declines through the hot weather from meteorological conditions, but for the late months of the year all is in doubt in the minds of consumers. If producers are not also beset with doubts it is curious that they refuse to accept orders for third quarter only at their second half price, requiring the buyer either to pay a premium for the third quarter alone, or take deliveries over the whole half.

The rail market for 1908 delivery has been opened, but orders are not coming in as rapidly as they usually do, the first four weeks of business showing only about 700,000 tons, including the tonnage of the Tennessee Company, which took orders before the Northern mills opened their books.

Specifications are coming in a little less rapidly than they were. Producers are indisposed to admit the fact, and make much of some new buying of steel bars by agricultural implement makers and other interests.

The condition is one which should be studied with the utmost caution by one who wishes to arrive at a correct diagnosis. Producers wish to squeeze out the last ton of orders possible from all existing contracts, and therefore have a great deal at stake in the continuance of popular confidence.

Much is said now, and much has been said in the past few years, about the extremely beneficial effect of the steadying policy of the United States Steel Corporation, and the application of the principle to what would otherwise be a period of depression. There is a fallacy in this. Similar influences will produce similar results in similar conditions, but not necessarily in dissimilar conditions. What has been shown is that in a period which would otherwise be one of mild fluctuations in demand and prices, the influence of the steel corporation produces steady demand and steady prices. This proves nothing as to results in a period which would otherwise be one of serious depression.

Let the previous state of the market be represented, as to demand, by a curve. It will show moderate ups and downs over short periods, of months or at most one or two years, with a grand swing up and down over ten-year periods. Now the influence of the steel corporation with its steady prices has been to eliminate these little movements. A prospective consumer sees that there is no prospect of any decline in the next year, and so he buys at once. Space is being borrowed from the future to fill up the little valleys in the curve, making a straight line along the peaks. It has not been shown that demand is created, merely that it is anticipated. Where can space be found to fill up the big valleys in the ten-year periods? Indeed, one is tempted to conclude that the anticipations of demand are going to make the depression all the more severe when it does come. Consumers have come to lean upon the steady arm of the steel corporation. When that support is withdrawn where will their dependence be?

These observations may be premature. The iron and steel trade is wound up to run well through the year, and on the surface is more prosperous now than it was a month, two months or three months ago. Possibly something may occur to carry the activity still farther, but the end of this high pressure must come some time, and the beginning of the end may be now.

Pig Iron.

Production has been steadily on the increase, due to the blowing in of idle furnaces and the completion of an occasional new one. A decline must come with the hot weather. While deliveries are fairly good, spot iron is quite scarce and commands high prices. As high as $30, Central Western furnace, has been paid for both No. 2 foundry and Bessemer in carload and 50-ton lots. Foreign iron continues to be a factor all along the seaboard, and is penetrating farther inland than before. There is more uncovered than unsold tonnage to Oct. 1, but beyond that date the situation may be quite different. The market has been advancing so that transactions a few days old no longer give a cue to the market, and we shall merely remark that while sales have been fairly large they have scarcely been up to normal, and then quote prices at this writing as follows, f. o. b. Central Western furnace: Bessemer and basic for June delivery, $24, in moderate sized lots and higher in small lots, for second half $23 to $23.50; No. 2 foundry, $25 and higher for June, $24 for third quarter, and $23 to $23.50 for fourth quarter or second half; gray forge $22. Some sales of foundry, malleable Bessemer and forge have been made for 1908, but none of Bessemer or basic. The Southern market is $21.50, Birmingham, for third quarter and $20 for fourth quarter, with $18.50 quoted on some inquiries which have been received for the early part of 1908.

Steel.

The Carnegie Steel Co. named $31 as the settlement price for June deliveries of sheet bars on monthly adjustment contracts. This is the minimum of the market. Purchases have been made from other mills at this figure for fourth quarter, and other orders have been offered and refused. Billets are not quotable accurately, being nominally about $30.50 for Bessemer and $32 to $33 for open-hearth at mill. The available supply of all crude steel is extremely limited. A peculiar condition has existed for several years, a period amply long to make the market forget that it is not necessarily permanent. That condition is that demand has been uniformly good for all finished steel products in proportion to the existing finishing capacity. Formerly the alignment was that there was a necessary excess of total finishing capacity relative to steel making and pig iron producing capacity. Finishing mills were then more flexible as to character of output than they are now. The present large finishing units are adapted to but a limited range. The finishing capacity is not only less flexible but more closely

approximates to the steel making and pig iron producing capacity. The time must come when demand for finished products will show more variation; some finishing departments will be filled with business and others will not. That will throw crude steel upon the market in a manner and volume never seen before, but the trade does not seem to have a glimmer of thought that such may be the case.

RAILS.

The Tennessee Coal, Iron & Railroad Co. will make about 350,000 tons of open-hearth rails in 1908, and has sold nearly all the tonnage. Surprise was caused when the Harriman lines, more naturally tributary to Chicago than to Alabama, placed 150,000 tons with the Tennessee company, avowedly because the product was open-hearth. The Harriman lines have had an unusually large number of broken rails, but it is probable that other influences, quite apart from considerations of quality, contributed to the decision. The Northern rail mills opened the order books for 1908 orders on April 17, and in the first four weeks booked fully 400,000 tons, the orders not coming in as rapidly as usual. The price of the Northern mills remains at $28, mill, where it has been since the spring of 1901. The Tennessee company advanced its price from $29 to $30, Birmingham.

FINISHED MATERIAL.

There has been a slight but significant decrease in the volume of new business and specifications on old contracts. The large mills insist that with absolute tonnage booked and reasonable prospects on contracts they have with steady consumers, their entire tonnage for this year is taken care of in shapes, plates and merchant steel bars. In wire, pipe and sheet products the mills are booked solidly for from three to five months, giving them enough momentum to carry them through the year, with a continuance of moderately favorable conditions. The market lacks the snap which it had, but on the surface appears perfectly sound.

The only change in prices, and that more or less a nominal one, comes through the issuing of a new list on merchant steel pipe by the leading interest, which fixes the inside price to jobbers at 74 and 5 off, on sizes ¾ to 6-inch, an advance of 2 points, or about $4 a net ton, on the list which was withdrawn March 8 last. The price is retroactive, a large tonnage having been booked *ad interim*, subject to such prices as should be announced later. Early deliveries command a point higher price, the independents only promising anything in the way of early deliveries. We quote other products unchanged, except that common iron bars are down $2 a ton for Pittsburg delivery and $1 a ton for Western delivery. Prices quoted are f. o. b. Pittsburg:

Structural shapes, $1.70 for beams and channels, 15 inches and under.

Plates, $1.70 for tank quality; early deliveries command premiums.

Merchant steel bars, $1.60, base.

Common iron bars, $1.70, delivered, Pittsburg; for Western delivery, $1.60 f. o. b., Pittsburg.

Sheets, 28 gauge, $2.60 for black, $3.75 for galvanized.

Tin plates, $3.90 for 100-pound cokes.

CORRESPONDENCE

The Electric Furnace in the Foundry.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—I was very much interested in the letter of Mr P. McN. Bennie, with reference to the electric furnace in the foundry, which appeared on page 75 of your March issue. Lack of time in connection with the convention of the American Foundrymen's Association, has prevented me from adding a few words in further explanation of my original suggestions.

Mr. Bennie, in his Philadelphia lecture, referred to the possibility of placing an electric furnace in the foundry with the idea of taking some of the melted iron from one or more cupolas and refining it to steel. In other words, to utilize the regular run of metal for small steel castings. I am afraid that this would not be practical for the ordinary foundry, inasmuch as the metal used for gray iron castings would not be suitable for steel making. If the electric process is carried on in an acid lining the "fancy" irons would have to be used with the attendant evil of sulphur additions, due to melting in the cupola. If the basic lining is used the phosphorus and sulphur might be cared for, but the other constituents might make trouble, as they are not properly proportioned for steel, if right for cast iron; that is, judging from the ordinary methods of making steel.

I am afraid that to make steel castings by refining the metal in the electric furnace on a small enough scale for the ordinary foundry would cost too much for skilled labor, while the works with larger demands for steel castings would naturally avoid a process costing more than $45 a ton for castings when pig iron is about $26.

As I see it, only a process taking scrap steel castings of an approximately correct composition, heating this up to white heat in an ordinary heating furnace, transferring it to the induction furnace, melting, adding the necessary ferromanganese, etc., and pouring, would find favor in the foundry.

So far as brass is concerned, the induction furnace would seem ideal. Any one who has had to do with the various types of oil-burning furnaces, knows that while they are mighty convenient the loss of metal is not only very great, but for certain classes of castings it is impossible to get sound results on account of the excessive oxidation. This is for the furnaces in which the gases play right on the metal. The crucible process is bad enough, and only the fact that the greatest care is taken with the metal used, and the adding of the easily oxidizible materials last, makes this old-fashioned and withal reliable method passably good. Where very thin scrap is used in the melt I have known 50 per cent to go up the flues.

Now, taking the induction furnace for this line of work, one can readily see advantages which, if some electrical concern would tackle the problem, would result in driving out all other forms of brass melting. With the temperature, a matter of regulation. With the atmosphere of the melt, non-oxidizing. With the taking up of foreign matter in a slag and the whole operation so self-contained that it is clean enough for the office. With practically no loss of metal during the melt, and the possibility of using 97 per cent of scrap and 3 per cent manganese as a final purifier, or the equivalent in manganese-copper, suppose the current does cost twice as much as the coke otherwise consumed, or even more. In the gray iron foundry the coke, or fuel, is by far the smaller end of the expense entering the cost of a casting. In brass melting this is not quite the case but the loss of zinc or tin is so costly a matter that it would quite overbalance a higher fuel charge.

We of the foundry industry certainly await developments that I understand are in process even now, with the greatest of interest from both the commercial standpoint and that of a distinct advance in a great industry.

WATCHUNG, N. J. RICHARD MOLDENKE

The Breakage of Steel Rails.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—According to newspaper reports a number of engineers attribute the frequent breakages in steel rails entirely to a faulty or careless system of rolling. I do not think that experienced practical steel makers coincide with this. If it was really due solely to rolling the breakages would be more universal and not exceptional, as in the mechanical operation

of rolling all rail products of the same section are being treated alike.

As a matter of fact, the trouble seems to be due principally to metallurgical defects in the steel. Practically all rail steel is being produced either in Bessemer converters or in basic open-hearth furnaces. These processes are of such a nature that the gases and the slag, resulting from conversion, cannot be entirely eliminated. Wherever these particles remain, and they may be distributed all through the rail, the steel is weak.

Without going into details, experience has taught that it is useless trying to correct these faults by mechanical means. It might improve the steel ingot to some extent, but it will never be equal to an ingot that has been cast thoroughly solid. As has been suggested, the weight of the rail might be increased by 20 to 30 per cent. Undoubtedly, this would give additional security, but to my mind it will not remove the principal cause of the trouble.

I am sustained in all the foregoing by the fact that in most cases of broken rails, whenever the question arose, whether the accident was due to faulty rails or extra hard wear, the only reliable tests made by the railroads to place the responsibility was by means of tests that positively proved that the steel rails were contaminated with oxides and slag in those parts that were responsible for the collapse.

I quote from an article by Mr. Robert Job in *Cassier's Magazine*, May issue:

"A short description of the method used to determine the cause of a rail failure may be of interest. In some cases, as, for example, when a bad pipe is present, the cause is evident at a glance. In other cases the prime cause may not be clear. An instance will point our meaning. A number of rails had mashed down in track after a few months' wear, and the mill refused to make replacement, claiming that the difficulty was due to the hard conditions of service. In order to determine the matter we took a representative section from one of the rails, polished the surface and etched for a few seconds with a solution of iodine. The characteristic appearance proved that the steel was so seriously contaminated with oxides and slag that little tenacity could be expected, and the wonder was that the rail had held together even as well as had been the case. With this evidence in hand the mill made proper replacement without further question.

"In some cases the condition of the rails adjacent in track may give some indication as to the cause of failure. In one location where a considerable number of rails had failed, it was found that both bad and good rails from the same rolling were in the same line of track adjoining one another and under precisely the same traffic conditions. A number of each type were removed and investigated. Analysis gave no clew, but upon light etching of the polished surfaces it was found that in every case in which failure had occurred the steel was unsound, whereas in every case in which normal results had been obtained the steel was almost perfectly free from this defect of unsoundness. We next examined the polished surface of the unsound steel under the microscope, and found that large numbers of holes and of oxide spots were present, and, in order to get the condition more clearly, we fractured the head of the rail along its length, and found that a large number of seam lines were present. In service the heavy wheel loads naturally forced the steel apart at these unwelded seams and thus caused the rail to crush. In the light of this evidence the true cause of the service failure was evident, and suitable action was taken by the mill in question."

Whatever trouble may be due to insufficient cropping of ingots, or faulty system of rolling, the steel makers are in position to remedy. It is, however, difficult to prove that the frequent rail breakages are due to these causes, whereas the presence of oxides and slag has been and can be established beyond doubt in most cases. With the present methods of making rail steel in Bessemer converters and basic open-hearth furnaces, it is however, impossible to produce a product absolutely free from oxides and slag. The only way to accomplish this and produce a uniform rail steel as well would be by passing the hot metal as it comes from the converter or open-hearth furnace through a large vessel free from oxidizing flames, for the purpose of keeping same at a dead melt and refining it.

It must also be borne in mind that owing to increased service requirements steel makers have been compelled to produce rails of much higher carbon, hence the metallurgical defects to which the main trouble is due are more aggravated, owing to the high carbon steel containing phosphorus and sulphur, the two most dangerous elements, considerably over .03 per cent. This might not be of such great consequence if steel rails were free from oxides and slag, but when all these dangerous elements happen to be combined trouble may surely be looked for.

The whole question resolves itself into this: Can steel rails be produced containing from .80 to 1 per cent carbon, phosphorus and sulphur not exceeding .02, and free from oxides and slag? If steel rail makers can guarantee to supply such an article to the railroads it would not only be the best guarantee for safety, but such a rail would outlast the present article bought by the railroads by many years, and they could easily afford to pay a higher price for such rails, as it not alone would mean a saving of life and limb, but great economy for the railroads in the long run. Steel Engineer.

New York City.

[The above letter of our correspondent is suggestive in various respects. In order to improve the rail metal we can either employ a special alloy steel or we can retain the ordinary steel and improve the metallurgical treatment of the metal in other respects. Nickel steel has been suggested, but at present its use or the use of other alloy-steels seems prohibitive on account of the expense. In discussing the rail-metal problem on another page of this issue, we have explained why we believe that the open-hearth rail is to come. But some points employed in the above letter of our correspondent suggest a further step; namely, the use of an electric furnace refining treatment subsequent to the open-hearth process. If such electric treatment is to be commercially successful it must be cheap, and to obtain the best results it must be a very large-scale operation. This suggests an electric steel mixer rather than an electric refining furnace. Dr. Héroult has pointed out and discussed the possibilities of such an electric steel mixer on page 30 of our Vol. IV.; and on page 173 of our last issue we mentioned the installation of a 150-ton steel mixer in a German steel works, employing the induction furnace. However, in the case of rail metal, to get the best results the mixer should not simply keep the metal in molten state and mix it, but it should be possible to produce chemical reactions in the same. In other words, we should have a mixer and electric refining furnace in one and the same apparatus. Dr. Héroult's scheme of employing the open-hearth process for reducing the phosphorus content down to any desired amount and then treating the dephosphorized and highly oxidized metal from several open-hearths in one large electric mixer for desulphurizing, deoxidizing and recarburizing is a special method deserving the most careful attention of steel makers. A process of this kind is distinctly feasible; a uniform product of desired composition in carbon, phosphorus and sulphur can thus be obtained, free from oxide and slag, and the only question is that of cost. In view of the large size of the mixer the electrical energy required per unit of output should be relatively small, and could be produced at a minimum cost from gas engines if blast-furnace gas is available. Moreover, the electric process permits the use of less ferro-alloys than would otherwise be required. This means a saving which reduces somewhat the expense for the electrical energy. In view of the present situation, with respect to rail metal, electrical methods —such as that outlined above or others—should find the attention which they deserve from a metallurgical standpoint.—Editor.]

The New Electrolytic Alkali-Works at Niagara Falls.

At the last meeting of the New York Section of the Society of Chemical Industry, Dr. L. H. Baekeland read a paper on the Townsend cell. He gave a record of the practical performance the cell has made during a continuous operation extending over almost a year and a half, in a large plant, using 1,000 hp. This was the first public reference which has been made on the subject, and we are glad to be able to report to our readers some of the statements made by Dr. Baekeland.

The speaker began by referring to *Electrochemical Industry*, Vol. I., p. 23, where, as far back as 1902, C. P. Townsend outlined, in a masterly way, the theoretical principles and problems involved in the electrolytic production of alkali and chlorine. Consistent with his theory, Townsend solved the problem of the diaphragm cell in an entirely new way. Many believe that the failures of the diaphragm cells are due to rapid deterioration of the diaphragm, and numerous patents have been taken out in different countries, with the object of improving the construction of this diaphragm. Some inventors went so far as to dispense entirely with diaphragms; as, for instance, in the gravity cell, where anolyte and catholyte are kept separate by difference in density. In other cases, liquid metals, as mercury or molten lead, are used as cathodes, so that the liberated sodium metal can form an alloy or amalgam.

The main object in electrolytic cells should be to counteract the tendency towards recombination of the alkali-hydrate liberated at the cathode with the chlorine set free at the anode. Diffusion renders this recombination possible, and, for that reason, whatever will restrict diffusion will also retard recombination. Recombination does not merely involve a loss of energy efficiency, by permitting some of the valuable products set free by electrolysis to recombine again—it means much more. Whenever chlorine acts on alkalihydrate a mixture of alkalichloride and alkalihypochlorite, or even chlorate, is formed. These latter oxygen compounds are decidedly harmful; in their turn they are split by the electric current, and they disaggregate the graphite anodes by a process of oxidation. This explains the rapid corrosion of graphite anodes in some electrolytic cells. Frequent analyses of the anode liquor will show large amounts of hypochlorite and chlorate in cells which are badly operated. Dr. Baekeland mentioned the fact that a large amount of hypochlorite or chlorate in anode liquor was a direct indication of low ampere efficiency and rapidly deteriorating anodes. He stated, furthermore, that many inventors of electrolytic cells have given scant attention to the following principles:

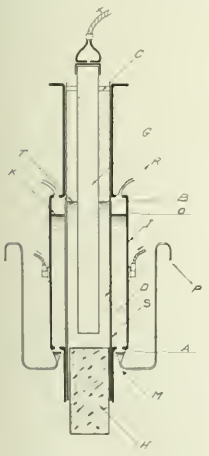


FIG. 1.—VERTICAL SECTION OF TOWNSEND CELL.

First. The rate of diffusion between anolyte and catholyte is a function of the concentration of the diffusing solutions.

Second. The amount of diffusion is a function of the time during which the given solutions remain in contact.

Third. The alkaline hydroxide in contact with the cathode, takes part in the electrolysis, and the liberated hydroxyl-ions tend to migrate towards the anode, where they act oxidizing

For these reasons gravity cells, working with an acceptable ampere-efficiency, give necessarily a weak caustic liquor

Among the many attempts which have been made to reduce recombination to a minimum, Dr. Baekeland mentioned the methods by which liberated sodium hydrate is transformed into less soluble or chemically less active compounds; as, for instance, submitting the cathode liquor to the action of carbonic gas, which transforms the alkalihydrate into carbonate or bicarbonate of sodium. He considers this transformation as a backward step, from a commercial standpoint, because it transforms high-priced caustic soda into low-priced carbonate.

He puts great stress on the fact that any cells, whether they be diaphragm cells or gravity cells, or liquid metal cathode cells, should not merely show favorable efficiencies. However high the latter may be they represent but partially the qualications of a good commercial cell. Even if a cell shows a maximum efficiency it may yet prove a commercial impossibility: if the cell is too delicate to be operated by men of average skill, or if the cost of maintenance and repairs is too

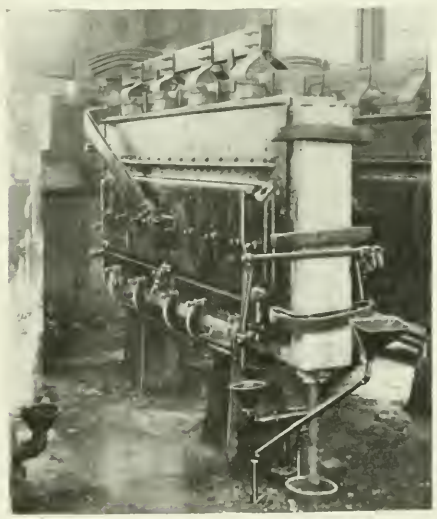


FIG. 2.—VIEW OF COMMERCIAL CELL.

high, or if the initial cost of the cell plant becomes exhorbitant

He pointed out that many mistakes have been made by experts, eminently well qualified as scientists, but who accorded insufficient importance to the commercial side of a new cell, neglected to take these matters into consideration and thus rendered a too optimistic opinion. Instead of determining how good a given cell is under the best conditions they should have tried to find out what "hard knocks" the apparatus could stand, for that reason some experts had failed to detect inherent weakness which resulted later in commercial failure

Townsend counteracts diffusion and recombination of cathions and anions by automatically substracting every drop of cathode liquor as soon as it appears, and surrounding it with a "chemically inactive and physically immiscible liquid." Kerosense is the liquid used in practice

Lantern slides illustrated his lecture Among them was one showing a diagram of a vertical cross-section of the Townsend cell (see Fig. 1) The anode space is enclosed between a lid (C), two vertical diaphragms (D), a non-conducting body (H) having the shape of a wide U (and of which only the section of the lower part is to be seen in the diagram); graphite anodes (G) pass through the lid of the cell and the protruding tops are connected by means of clamps to the electric generator; the diaphragms are in close contact with perforated iron cathode plates (S) The latter are fastened to two iron sides (I), bulging outwards in the middle,

which form what is called the cathode compartment. The middle space contains saturated brine (T), while the cathode compartment contains kerosene oil (K). On account of the difference in specific gravity between the two liquids there is a hydrostatic pressure from the anode compartment toward the cathode compartment. Even if the level of the two liquids be the same there is a tendency of the brine in the anode compartment to press through the diaphragm and flow into the kerosene. If the electric current be turned on the percolating brine becomes cathode liquid and carries caustic hydrate. The strength in caustic will increase according to the number of amperes which are sent through the cell. Furthermore, each drop of liquid as soon as it traverses the diaphragm runs through the perforations of the anode plate, acquires a globular shape, by a capillary phenomenon, produced on contact with the kerosene oil. This provokes a rapid separation of the aqueous liquid, so that every drop as soon as it forms detaches itself rapidly, sinks to the bottom of the oil and ac-

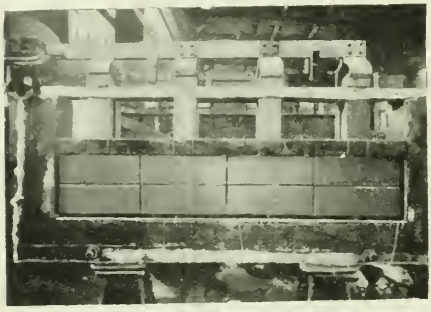


FIG. 3.—BODY OF CELL WITH SIDE PLATE REMOVED.

cumulates into a small caustic pocket (A). This puts it entirely outside of the zone of possible chemical or physical action. A goose-neck tube P drains this liquid from the supernatant oil, and thereby avoids its accumulation beyond desirable quantities. The inflow and overflow of the brine in the anode compartment are so regulated as to maintain a steady level. By a simple contrivance, which will be described hereafter, this level can be increased or decreased at will, thus controlling the hydrostatic pressure in the inside of the anode compartment. This gives a simple means of increasing the rate of percolation, and thereby producing stronger or weaker caustic liquor, in accordance with the density of the electric current.

That is, in short, the way this ingenious cell was conceived

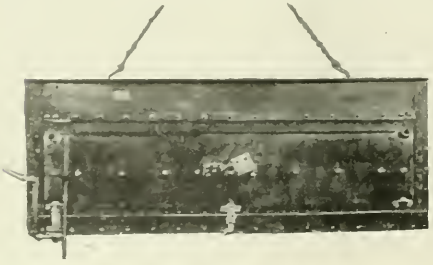


FIG. 4.—SIDE PLATE OF CELL.

by Mr. C. P. Townsend, in collaboration with Mr. Elmer A. Sperry, who contributed in a large measure to the engineering features of the apparatus."

Dr. Baekeland mentioned further that as soon as the cells were submitted to long practical tests many improvements suggested themselves, and he found it advisable to change some of the mechanical features so as to make them better adapted to regular operation on a large scale. However, the original idea of the Townsend cell was respected.

Photographs were shown of the cells which had been in continuous operation since the beginning of 1906, in sets of 64 cells, each of them carrying from 2,000 to 2,300 amps. New cells are now under construction which will carry 4,000 amps. each. These cells are operated under an extraordinary heavy current density: about 1 amp. per square inch of anode surface.

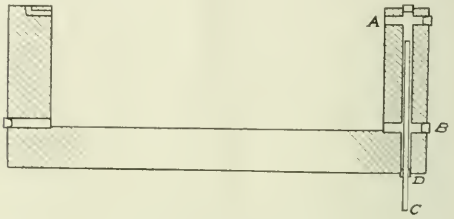


FIG. 5.—CHANNELS IN CELL BODY.

The cells measure about 8 feet long, 3 feet high and 12 inches wide (Fig. 2). They consist of a U-shaped non-conducting body, made of cement concrete (Fig. 3), against which are clamped two iron side plates (Fig. 4), bulging out in the middle and provided with flat borders; inside they carry a perforated cathode sheet, against which is applied the diaphragm—a description of which follows further. A rubber gasket enables the making of a tight fit when the side plates are clamped against the concrete body. For this purpose strong steel clamps hold the whole system rigidly together. Removing a few clamps enables the opening of the cell and the inspection of every part of it, and reassembling a cell requires but a very short time.

In order to maintain a steady level of the anode liquid the

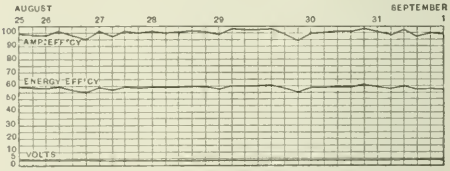


FIG. 6.—EFFICIENCY CURVES.

U-body is provided with a system of stoneware channels, which are imbedded in the cement concrete (Fig. 5). The upper cross channel (A) allows an exit for the gas, the lower (B) is intended as a flush-hole for cleaning the bottom of the cell. A glass tube (C) slides into the vertical channel through a perforated stopper (D). By moving this tube up and down a variable position can be given to the overflow, and, in this way the height of the liquid can be adjusted so as to control the hydrostatic pressure in the anode chamber. Merely changing the position of this glass tube produces, at will, a weak or strong caustic liquor. The overflowing brine is considerably weaker when it leaves the cell, and before it is fed anew it requires resaturation. How this is effected will be described later on.

A slight depression at the bottom of the iron side plates provides a caustic pocket where the cathode liquor accumulates, but the accumulated liquid never exceeds more than a few cubic centimeters, because it is steadily drained off by means of an adjustable iron pipe, which conveys the caustic liquor from underneath the kerosene—very much in the same way as the goose-neck tube of the classical Florentine flask. In this

manner the rich cathode liquor runs out both sides of the cell in two continuous, thin streams, which are collected in a funnel-like contrivance, from where the liquid is carried to pipe lines into the general caustic storage tank. From there it goes to the evaporating pans, where the remaining salt is

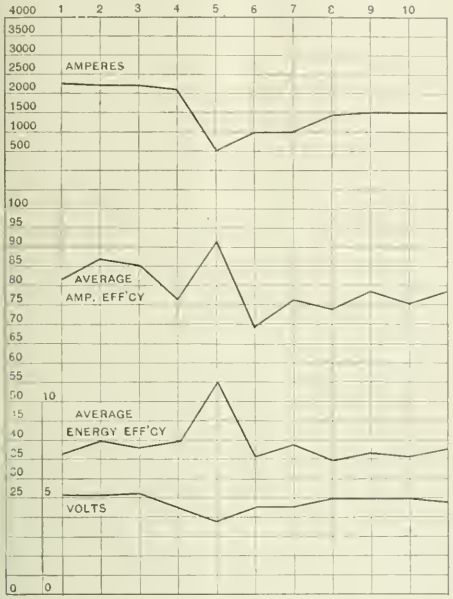


FIG. 7.—RELATION BETWEEN EFFICIENCY AND CURRENT DENSITY.

separated by concentration. Under these conditions the whole cell plant runs automatically and very little supervision is necessary.

There is a slight loss of kerosene, mainly due to evaporation and to mechanical waste, but the loss does not exceed a couple of dollars per day for a very large plant.

The whole construction of the cell is such that the initial cost is relatively very small. According to Dr. Baekeland the mercury alone of mercury cells represents several times the cost of a complete Townsend cell of the same capacity, which means, of course, a considerable economy in the initial cost of the plant, and also a lessening in the cost of amortization and maintenance.

The first diaphragms used in the Townsend cell were made of asbestos paper, but this necessitated delicate handling, and the expense for renewals was quite considerable. During the last fourteen months the whole plant has been operated with diaphragms after Baekeland's patent. The latter consist of a woven sheet of asbestos cloth, of which the pores are filled with a special mixture of oxide of iron, asbestos fiber and colloid iron hydroxide. The latter material produces a sort of binder for the asbestos fiber and the oxide of iron; its function is somewhat similar to that of rosin or glue size in the manufacture of asbestos paper, but it has a great advantage over organic sizes, in that it does not become gummy in contact with

FIG. 9.—INSIDE VIEW.

sodium hydrate. The mixture is applied with a brush and painted on as ordinary paint. Whenever a diaphragm has to be renovated the surface is simply scrubbed and washed with water; a new coat of paint is applied, and after this is dry the diaphragm is again ready for use. This process has only to be repeated at long intervals, and requires but a few minutes. A diaphragm may not require repainting for several months. Even when impure or unsettled brine is used the painting has to be done only about once in five weeks.

If the cells are run with proper care the Acheson graphite anodes last astonishingly long. In some experiments where cells were operated with especial attention, corrosion was so slight that delicate scratches which had been made with the point of a needle on the surface of the anodes showed very

FIG. 8.—NIAGARA PLANT OF DEVELOPMENT & FUNDING CO.

directly and with no alteration after several months of continuous operation. Even under the worst conditions the anodes only require partial renewal after about one year of continuous hard service.

Dr Baekeland went on describing his patented system for resaturating spent anode liquor, a rather difficult problem of chemical engineering, if we take into consideration that the liquor, after it leaves the cells, shows Sp. Gr. 1.18, and has to be brought up rapidly to Sp. Gr. 1.2. The liquid is hot and carries uncomfortable amounts of chlorine gas, so that it cannot come in contact with any metal or other material which is attacked by chlorine. For a large plant hundreds of thousands of gallons of this liquid have to be resaturated and filtered daily. His system has been in continuous service for about sixteen months. For the description of the process we refer to United States patent No. 844,314.

As to the efficiencies of the cells they are truly remarkable. In special tests (Fig. 6), where the cells were operated under very favorable conditions, it was possible to maintain an ampere efficiency quite close to 100 per cent, the voltage not exceeding 3.4 volts to 3.6 volts; but in practice these ideal conditions are seldom realized; where a large set of cells have to be operated at the same time their efficiency has often to be sacrificed to expediency. But even then ampere efficiencies ranging between 96 per cent and 97 per cent are not unusual under a load of about 1 amp. per square inch of anode surface. Under abnormally defective conditions, which were the result of some disturbance in the plant outside of the cell room, the ampere efficiency seldom dropped below 90 per cent during nearly a year and a half of operation.

It was pointed out how absurd it is to talk about ampere efficiencies or energy efficiencies of an electrolytic cell without mentioning the other factors, and especially without comparing current density. In order to illustrate this a curve was shown (Fig. 7) of some cells running under unusually poor efficiencies but under a load of 1 amp. per square inch. Reducing the load to about $^1/_4$ amp. per square inch (which even then is a current density higher than most known cells are run) it was possible to bring up the ampere efficiency to 93 per cent, the energy efficiency to 55 per cent, and to drop the voltage from 5 volts to 3.4 volts.

It has been pointed out that the strength of the caustic liquor produced in the Townsend cell can be regulated at will by increasing or decreasing percolation in conjunction with the strength of the current. By reducing percolation, cathode liquor containing 250 grams of NaOH per liter or more can be produced. In practice it is found advantageous to produce liquor containing about 150 grams of NaOH per liter. Such liquor carries also about 213 grams of salt. The latter is separated by evaporation from the caustic lye and is used over again.

The Niagara plant (Fig. 8) where the Townsend cell has been in continuous operation since the beginning of 1906, has been producing daily an average of 5 tons of caustic soda and 11 tons of high grade bleach. On the strength of what has been accomplished the plant is about to be increased to a fourfold capacity.

Society of Chemical Industry.—At the last meeting of the season of the New York Section of the Society of Chemical Industry, held at the Chemists' Club on May 24, Messrs. A. Hough and A. Moscovici presented a paper on the manufacture and properties of nitro-starch and the use of nitrogen pentoxide for the preparation of nitroglycerine and mannitol nitrate. Dr. Clifford Richardson spoke on improvements in modern asphalt pavements in Europe and America. Dr. Leo Baekeland presented a fully illustrated paper on the Townsend cell for the electrolytic manufacture of caustic soda and chlorine. This is very fully abstracted in the above article. A paper by Mr. W. R. Ingalls on the production and consumption of sulphuric acid was read by title.

Metallurgical Calculations.

By J. W. Richards, Ph. D.
Professor of Metallurgy in Lehigh University.

Roasting and Smelting Copper Ores.

The facts with regard to the metallurgy of copper may be found in condensed form, very clearly stated, in Schnabel's "Handbook of Metallurgy," Vol. I.; they may be found discussed at greater length in Dr. Peters' "Modern Copper Smelting" and "Principles of Copper Smelting," in Eissler's "Hydrometallurgy of Copper," and in Ulke's "Modern Electrolytic Copper Refining." In the present presentation it will be possible to merely enumerate the different processes concerned, the principles embodied in each and the methods of calculating quantitatively the nature of the reactions involved.

The chief ore of copper is chalcopyrite, $CuFeS^2$ which contains when pure approximately 30 per cent iron and 35 per cent each of copper and sulphur. It is most frequently found mixed with silica, SiO^2, as gangue, although various other gangue materials are sometimes present. This mineral is fusible, and if it were merely melted out of the enclosing rock, in an atmosphere which did not act upon it, it would merely lose one-fourth of its sulphur and melt to a fluid double sulphide of iron and copper, according to the following reaction:

$$2CuFeS^2 = Cu^2S \cdot 2FeS + S.$$

The melted sulphide of copper and iron resulting is called "matte," and, in fact, any mixture of Cu^2S and FeS in any proportions is called matte, and in practice may contain small quantities of PbS, ZnS, BaS, NiS, As, Sb, Te and even of Fe^3O^4, which is slightly soluble in these fused sulphides. In the majority of cases the matte is practically near enough to a mixture of Cu^2S and FeS to regard it as containing only those two substances.

Since the first operation in the extraction of copper from its usual sulphide ores is invariably the concentration to matte, we will first study the composition of this substance. Assuming matte to consist of Cu^2S and FeS in varying proportions, we may note that if it is all Cu^2S it contains $2 \times 63.6 = 127.2$ parts of copper to 32 parts of sulphur, or practically 4 copper to 1 sulphur, or is 80 per cent copper. For every 1.0 per cent of copper sulphide present there is, therefore, 0.8 per cent of copper in the matte; and, conversely, for every 1 per cent of copper in the matte there is 1.25 per cent of copper sulphide in it. The rest of the matte being iron sulphide, which contains 56 parts iron to 32 sulphur, it can be seen that the percentage of iron can be calculated for any per cent of copper; in fact, the per cent of copper fixes both that of iron and sulphur.

Illustration: A matte contains 40 per cent copper. How much iron and sulphur does it contain? How much copper sulphide and iron sulphide?

40 per cent copper $= 40 \times 5/4 =$	50	per cent Cu^2S.
$100 - 50 =$	50	" FeS.
50 per cent $FeS = 50 \times 56/88 =$	31.8	" Fe.
$100 - (40 + 31.8) =$	28.2	". S.

We may generalize this solution and say that if X represents the percentage of copper in a matte, that the composition of the matte is as follows:

Per cent of copper	$= X$
Per cent of Cu^2S	$= 1.25\ X$
Per cent of FeS	$= 100 - 1.25\ X$
Per cent of Fe $= (100 - 1.25\ X)\ 56/88 =$	$63.6 - 0.795\ X$
Per cent of S $= 100 - X -$ Fe	$= 36.4 - 0.205\ X$

Similarly, if Y represents the percentage of iron in a matte its composition is:

Per cent of Fe	$= Y$
Per cent of FeS	$= 1.57\ Y$
Per cent of Cu^2S	$= 100 - 1.57\ Y$
Per cent of Cu	$= 80 - 1.26\ Y$
Per cent of S	$= 20 + 0.26\ Y$

Finally, if Z represents the percentage of sulphur in a matte its composition is:

Per cent of S	$= Z$
Per cent of Fe	$= 3.89\ Z - 77.8$
Per cent of Cu	$= 177.8 - 4.89\ Z$
Per cent of FeS	$= 6.11\ Z - 122.3$
Per cent of Cu^2S	$= 222.3 - 6.11\ Z$

The following tables may be then drawn up, and will be found useful for reference:

Percentages.

Cu.	*Fe.*	*S.*	*Cu^2S.*	*FeS.*
80	0.0	20.0	100.0	0.0
75	4.0	21.0	93.8	6.2
70	8.0	22.0	87.5	12.5
65	12.0	23.0	81.3	18.7
60	15.9	24.1	75.0	25.0
55	19.9	25.1	68.8	31.2
50	23.9	26.1	62.5	37.5
45	27.9	27.1	56.3	43.7
40	31.8	28.2	50.0	50.0
35	35.8	29.2	43.8	56.2
30	39.8	30.2	37.5	62.5
25	43.8	31.2	31.3	68.7
20	47.7	32.3	25.0	75.0
15	51.7	33.3	18.8	81.2
10	55.7	34.3	12.5	87.5
5	59.7	35.3	6.3	93.7
0	63.6	36.4	0.0	100.0

For regular use in a smelting works it is easy to calculate out a table similar to the above for every 1 per cent of copper, and keep it under a glass cover for constant reference. Or, if preferred, a large piece of cross-section paper can be taken, and a diagram prepared with the percentages of copper as abscissas, from 0 to 80, and with ordinates running up to 100. A line drawn from an ordinate 36.4 at abscissa 0 to ordinate 20 on abscissa 80, will represent the sulphur content; a line from ordinate 63.6 on abscissa 0 to ordinate 0 on abscissa 80, will represent the iron content; a line from 0 to ordinate 100 on abscissa 80 will represent the Cu^2S content; and a line from ordinate 100 on abscissa 0 to ordinate 0 on abscissa 80 will represent FeS content.

It has been already shown that if a chalcopyrite ore were smelted down, as in a shaft furnace, to a matte, that about a 35 per cent matte is as rich as could be made by simple fusion. In fact, a much poorer matte would usually result, because chalcopyrite is often accompanied by pyrite, FeS^2, and which on simple heating becomes FeS, and thus dilutes the matte still further.

Illustration: A chalcopyrite copper ore contains 30 per cent by weight of chalcopyrite and 25 per cent of iron pyrites. What grade of matte would result from a simple fusion of this ore, without roasting, in a reducing atmosphere? Thirty per cent $CuFeS^2$ contains:

$30 \times 160 \div 336$	$= 13$ per cent	Cu^2S.
$30 \times 176 \div 336$	$= 14$ "	FeS.
25 per cent of FeS^2 will produce		
$25 \times 88 \div 120$	$= 18$ "	FeS.
Total matte	$= 45$ "	of the ore.

Composition of matte:

$Cu^2S = 29$ per cent $= 23$ per cent copper.
$FeS = 71$ "

It is thus seen that the presence of iron pyrites in the ore tends to lower the grade of the matte produced.

The essential principle of the metallurgy of copper is now before us. It is this fact: that if some of the sulphur in the ore be first removed by roasting, and this operation be followed by smelting, the copper will first take enough of the sulphur to form Cu^2S, and then what sulphur is left over will form FeS. The amount of FeS which will accompany the Cu^2S into the matte is entirely a question of how much sulphur is left to combine with iron after all the copper has been satisfied, and this amount of sulphur can be exactly controlled by the preliminary roasting.

Illustration: Taking the ore mentioned in the previous illustration, containing 30 per cent of chalcopyrite (= 10.4 per cent of copper) and 25 per cent of iron pyrites, what per cent of sulphur does it contain, and what would be the quality of the matte produce by fusion in a reducing atmosphere if the sulphur were previously roasted down to ½ or ¼ or ⅛ of its original amount?

Sulphur in 30 per cent chalcopyrite:
$30 \times 128 \div 308 = 10.5$ per cent.
Sulphur in 25 per cent pyrites:
$25 \times 64 \div 120 = 13.3$ "
Total $= 23.8$ "

If the sulphur were reduced to ½, ¼ or ⅛ its original amount there would remain, out of the 23.8 per cent, either 11.9, 5.95 or 2.97 parts of sulphur per 100 of original ore; *i. e.*, per 10.4 parts of copper. The 10.4 of copper requires 2.6 of sulphur to form Cu^2S, leaving the following amounts of sulphur in excess to form FeS:

Sulphur left in ore.....	11.90	5.95	2.97
Sulphur needed for Cu^2S.....	2.60	2.60	2.60
Sulphur left to form FeS.....	9.30	3.35	0.37
FeS which will be formed.....	14.61	5.26	0.58
Cu^2S formed	13.00	13.00	13.00
Matte formed	27.61	18.26	13.58
Per cent of Cu in matte.....	37.7	57.0	76.6

It is thus evident that the degree of the previous roasting determines absolutely the quality or grade of the matte formed on the subsequent smelting.

It can be readily seen that since partial roasting virtually oxidizes a portion or fraction of the ore, that it is the practical equivalent of roasting if we can get oxide ore to mix with sulphide ore. The raw oxide ore acts exactly as so much roasted ore, and thus enriches the matte on subsequent smelting.

Illustration: What proportion of a cuprite (copper oxide) ore, free from sulphur and containing 28 per cent of copper, can be mixed with the chalcopyrite ore of the previous illustrations, to produce a matte on subsequent reducing smelting containing 50 per cent of copper?

One hundred parts of the chalcopyrite ore contains 10.4 parts Cu. 20.8 parts Fe, 23.8 parts S.

The sulphur, however, is not all available for making matte, because one-fourth of the sulphur in chalcopyrite and one-half that in pyrite is given off by simple heating. There would be lost, therefore, and not available for matte, sulphur as follows:

S in chalcopyrite $10.5 \times ¼ = 2.6$ not available.
S in pyrite $13.3 \times ½ = 6.7$ " "
9.3 " "

Available sulphur $= 23.8 - 9.3 = 14.5$ parts per 100 of ore.

In a 50 per cent matte there is (see previous table) 26.1 per cent of sulphur; 14.5 parts of sulphur available for matte is therefore capable of producing $14.5 \div 0.261 = 55.5$ parts of 50 per cent matte, which would contain 27.75 parts of copper. But there is only 10.4 of copper in the chalcopyrite ore, leaving therefore 16.35 of copper to be supplied by the cuprite ore, and therefore capable of taking up $16.35 \div 0.28 = 58$ parts of the oxide ore per 100 of the sulphide ore. A mixture of 100 of the sulphide ore and 58 parts of the oxide ore would therefore smelt down in a reducing atmosphere to a 50 per cent matte.

We have carefully specified a reducing atmosphere as the condition for smelting down to produce the calculated results, because under these conditions the oxygen of the roasted ore or of the raw oxide ore added cannot combine with the sulphur of the ore and go off as SO^2, but is taken up by the carbon or CO in the smelting furnace. In smelting in a shaft furnace with carbon as fuel these conditions exist, and the sulphur in the charge can be counted on as practically all forming matte. If the smelting is done in a reverberatory furnace, with a neutral atmosphere, much sulphur will be removed from the charge by the oxygen of the roasted ore or of the raw ore added, and a richer matte results. The reactions of this elimination of sulphur are mostly

$$Cu^2S + 2CuO = 4Cu + SO^2$$
$$Cu^2S + 2Cu^2O = 6Cu + SO^2$$

On an average, a matte 10 per cent richer in copper will be obtained from a given roasted ore by smelting it down in a reverberatory furnace, where these reactions between sulphide and oxide of copper can occur, than in shaft furnace smelting with coke, in which the oxygen of the charge is taken up by the carbon.

There is a third variety of smelting which is in reality a combined roasting and smelting-down operation. We refer to what is called pyritic smelting, where a sulphide ore is roasted in a blast of air so rapidly that the heat generated melts down the charge and produces a concentrated matte. This operation is done on pure sulphides, however, without preliminary roasting, and will be subsequently treated by itself.

The Roasting Operation.

When an ore is roasted it loses some sulphur and takes up oxygen. The roasted ore will therefore have a different weight from the unroasted ore. Thus:

100 parts of Cu^2S become	90.0	parts of	Cu^2O.
100 parts of Cu^2S become	100.0	"	CuO.
100 parts of Cu^2S become	100.0	"	$CuSO^4$.
	50.0	"	CuO.
100 parts of FeS^2 become	64.4	"	Fe^2O^4.
100 parts of FeS^2 become	125.0	"	$FeSO^4$.

Problem 101.

A pyritous copper ore from Ely, Vt. (see Peter's "Modern Copper Smelting," p. 133), contained before and after roasting, in percentages:

	Before.	*After.*
Sulphur	32.6	7.4
Copper	8.2	9.1

The condition of the copper in the roasted sample was determined as

	Per Cent.
Copper as $CuSO^4$	1.3
Copper as CuO	2.1
Copper as Cu^2S	5.7

Required:

(1) The weight of roasted ore per 100 of raw ore.

(2) The proportion of the sulphur removed by roasting.

(3) The grade of matte which would be formed by smelting down in a reducing atmosphere in a shaft furnace.

(4) The grade of matte which would be formed by smelting down in a neutral atmosphere in a reverberatory furnace.

Solution:

(1) Since no copper is lost, there will be produced per 100 of raw ore:

$$100 \times \frac{8.2}{9.1} = 90.1 \text{ of roasted ore.} \qquad (2)$$

(2) Sulphur in 100 of raw ore = 32.6 *Parts.*

Sulphur in 90.1 of roasted ore $= 90.1 \times 0.07 \times 4 =$ 6.7

Sulphur eliminated = 25.9

Proportion removed:

$$\frac{25.9}{32.6} = 0.793 = 79.3 \text{ per cent.} \qquad (2)$$

(3) Per 100 of roasted ore we have:

	Kg.
Sulphur to form $Cu^2S = 9.1 \times 0.25$	= 2.3
Sulphur to form $FeS = 7.4 - 2.3$	= 5.1
FeS formed $= 5.1 \times 88/32$	= 14.0
Cu^2S	= 11.4
Matte formed	= 25.4

$$\text{Per cent of copper} = \frac{9.1}{25.4} = 0.358 = 35.8 \text{ per cent.} \qquad (3)$$

(4) In

$$CuSO^4 + Cu^2S = 3Cu + 2SO^2$$

every 1 part of copper as $CuSO^4$ reduces two parts of copper as Cu^2S, and causes the elimination as gas of 1 part of sulphur. In

$$2CuO + Cu^2S = 4Cu + SO^2$$

1 part of copper as CuO reduces 1 part of copper as Cu^2S, and causes the elimination of one-fourth its weight of sulphur. Therefore, the sulphur eliminated by the reactions given is:

	Parts.
By reaction of sulphate on sulphide 1.3×1	= 1.3
By reaction of oxide on sulphide $2.1 \times \frac{1}{4}$	= 0.5
Total	= 1.8
Sulphur remaining to form matte $= 7.4 - 1.8 =$	5.6
Sulphur needed to form Cu^2S	= 2.3
Sulphur left to form $FeS = 5.6 - 2.3$	= 3.3
FeS formed $= 3.3 \times 88/32$	= 9.1
Cu^2S formed	= 11.4
Matte formed	= 20.5

$$\text{Per cent of copper} = \frac{9.1}{20.5} = 0.444 = 44.4 \text{ per cent.} \qquad (4)$$

In the roasting of ores a large amount of heat is set free, since both the sulphur and the metal are usually oxidized.

Problem 102.

In the ore of Problem 101, taking the data given for its weight before and after roasting, how much heat was generated in its roasting per kilogram of ore treated?

Solution: Starting with 100 parts of original ore it contained 32.6 parts of sulphur and 8.2 of copper. The latter corresponds to 2.05 of sulphur as Cu^2S, which would mean 8.2 of sulphur altogether as chalcopyrite, leaving 24.4 of sulphur present in the ore as iron pyrites.

In 100 of the roasted ore we have 5.7 parts of copper as Cu^2S, therefore unchanged, 2.1 parts changed to CuO and 1.3 parts changed to $CuSO^4$. These contain sulphur as follows:

	Parts.
Sulphur for 5.7 Cu as Cu^2S	= 1.4
Sulphur for 1.3 Cu as $CuSO^4$	= 0.7
Sulphur for copper compounds	= 2.1
Sulphur for $FeS = 7.4 - 2.1$	= 5.3
$FeS = 5.3 \times 88/32$	= 14.6

Per 90.1 of roasted ore there is present:

Cu as $CuSO^4$	= 1.17
Cu as Cu^2S	= 5.14
Cu as CuO	= 1.89
Fe as $FeS = 9.3 \times .901$	= 8.38
Sulphur	= 6.67

We therefore have:

Heat to Decompose Raw Ore.

		Calories.
8.20 Cu as Cu^2S	= 8.20 × 160 =	1,312
18.85 Fe as sulphide	= 18.85 × 429 =	8,087
	Sum =	9,399

Heat of Formation of Products.

5.14 Cu as Cu^2S	= 5.14 × 160 =	862
1.17 Cu as $CuSO^4$	= 1.17 × 2,857 =	3,343
1.89 Cu as CuO	= 1.89 × 593 =	1,121
25.93 S to SO^2	= 25.93 × 2,164 =	56,112
9.55 Fe to Fe^2O^4	= 9.55 × 1,612 =	15,395
9.30 Fe to FeS	= 9.30 × 429 =	3,990
	Sum =	80,783

Net heat evolved = 80,783 — 9.399 = 71,384 Calories.
Per 1 kg. of ore = 713 "

In the roasting of copper ore the heat generated by the oxidation of the ore is an important item in the heat required by the furnace. In the above case, for instance, each kilogram of ore developed about one-tenth as much heat as a kilogram of coke, and with proper arrangements for conserving heat, such as thick walls and compact shape of furnace, combined with regeneration of heat from the cooling ore, there is no reason why such an ore should not be made to roast itself. Such a scheme, when practicable, is highly economical in districts where fuel is dear. A long-bedded calciner, with its single hearth and large radiating surface, cannot meet these conditions, but furnaces having superposed hearths and arrangements for discharging cold ore, cooled by the incoming air, such as the Spence and MacDougal furnaces, can work on many ores without using other fuel.

Problem 103.

An improved Spence furnace used at Butte, Mont., calcines 90,000 pounds of concentrates in 24 hours, of the following composition:

	Per Cent.
Copper	9.8
Iron	33.8
Silica	13.3
Sulphur	41.2

Four-fifths of the sulphur is removed, and the roasted ore is practically discharged cold; 1,500 pounds of slack coal, calorific power 6,500, is used per day. The furnace gases contain:

	Per Cent.
CO^2	0.6
SO^2	7.2
H^2O	0.6
N^2	81.3
O^2	10.3
	100.0

and escape into the chimney at 200° C. Ore charged and discharged cold. Furnace has an outside radiating surface of 5,000 square feet.

Required:

(1) The heat balance sheet of the furnace.

(2) The proportion of the heat generated by the roasting of the ore and by the combustion of fuel.

(3) The heat radiated and conducted to the air per square foot of outside surface per minute.

Solution:

(1) Per 100 of ore used the unroasted and roasted ore will contain, respectively:

Copper	9.8	9.8
Iron	33.8	33.8
Silica	13.3	13.3
Sulphur	41.2	8.2

Assuming that the copper remains in the roasted ore, two-thirds as Cu^2S, one-quarter as CuO and one-tenth as $CuSO^4$, while the iron takes the rest of the sulphur to form FeS, the excess of iron forming half Fe^2O^3 and half Fe^3O^4. We have the composition of the roasted ore as:

Cu^2S	8.2
CuO	3.1
$CuSO^4$	2.0
FeS	17.0
Fe^2O^3	16.4
Fe^3O^4	15.9
SiO^2	13.3
	75.9

The copper and iron existed in the unroasted ore virtually as Cu^2S, FeS and FeS^2, and therefore the 8.2 of Cu^2S and the 17.0 of FeS in the roasted ore can be considered as unchanged. The actual change in the roasting has been the formation of 3.1 CuO and 2.0 $CuSO^4$ from Cu^2S, and the formation of 16.4 Fe^2O^3 and 15.9 Fe^3O^4 from FeS. If we, therefore, subtract from the heat of formation of these amounts of CuO, $CuSO^4$, Fe^2O^3 and Fe^3O^4, and the SO^2 formed, the heat required to resolve the Cu^2S, FeS and FeS^2 into their constituents, we shall get the net heat evolution in the roasting process. The heats of formation involved are:

Molecular Heat.

(Cu^2, S)	= 20,300	Calories	= 127	Cal. per kg. of product.	
(Cu, O)	= 37,700	"	= 471	"	" "
(Cu. S, O^4)	= 181,700	"	= 1,136	"	" "
(Fe, S)	= 24,000	"	= 273	"	" "
(Fe^2, O^3)	= 195,600	"	= 1,223	"	" "
(Fe^3, O^4)	= 270,800	"	= 1,167	"	" "
(S, O^2)	= 69,200	"	= 1,082	"	" "

We then have the heat evolved and absorbed as follows:

Evolved.

		Calories.
Formation of CuO	3.1 × 471 =	1,460
Formation of $CuSO^4$	2.0 × 1,136 =	2,272
Formation of Fe^2O^3	16.4 × 1,223 =	20,057
Formation of Fe^3O^4	15.9 × 1,167 =	18,555
Formation of SO^2	66.0 × 1,082 =	71,412
	Total =	113,756

Absorbed

Decomposition of Cu^2S	4.1 × 127 =	521
Decomposition of FeS	36.1 × 273 =	9,855
	Sum =	10,376

Net heat evolution per 100 of concentrates:

113,756 — 10,376 = 103,380 Calories.

The gases contain 33 pounds of sulphur for every 100 of ore roasted, and the analysis shows there is 0.072 cubic foot of SO^2 in each cubic foot of chimney gas. This weighs 0.072 × 2.88 = 0.2074 ounces and contains just half its weight = 0.1037 ounces = 0.00074 pounds of sulphur. There is therefore produced, per 100 pounds of ore, 33 ÷ 0.00074 = 4,896 cubic feet chimney gas

This contains, from its analysis:

CO^2	29
SO^2	353
H^2O	29
O^2	504
N^2	3,981

And at 200° C. carries off up the chimney as follows:

S_m (0 — 200°)

CO^2	29 × 0.414 =	12	oz. cal.	per 1°.
SO^2	353 × 0.420 =	148	"	"
H^2O	29 × 0.370 =	11	"	"
O^2, N^2	4.485 × 0.308 =	1,381	"	"
	Sum =	1,552	"	"
	=	97	lb. Cal.	per 1°.
	=	19,400	lb. Cal.	per 200°.

The fuel evolves 6,500 × 1,500 = 9,750,000 pounds Calories per day = 10,830 pounds Calories per 100 of ore roasted.

(1) Balance Sheet Per 100 of Ore Roasted. (1)

	Lb. Calories.
Evolved by the fuel	10,830
Evolved by the roasting operation	103,380
Sum	114,210
Loss in chimney gases	19,400
Loss by radiation and conduction	94,810
Sum	114,210

(2) The proportion of the total heat generated by the ore itself is:

$$\frac{103,380}{114,210} = 0.90 = 90 \text{ per cent.}$$

by the fuel 10 " (2)

The heat lost by radiation and conduction per day is:

	Lb. Calories
94,810 × 900	= 85,329,000
Per minute	= 59,000
Loss per square foot of surface, per minute $\frac{59,000}{5,000}$	= 11.8 (3)

Problem 104.

The Evans-Klepetko cylindrical roaster used at Butte, Mont., is 19 feet high, 18 feet in diameter, and roasts 80,000 pounds of concentrates daily from 35 per cent sulphur down to 7 per cent (Dr. Peters). The evolution of heat in the roasting operation is sufficient to supply all the heat needed. The stirrer arms are cooled by water circulation, 100 pounds of water being used per minute, and raised in temperature 50° C. Assume the evolution of heat to be 90 per cent as great as in the roasting of ore in Problem 103, and the chimney loss to be correspondingly smaller.

Required:

(1) The heat balance sheet per 100 of ore roasted.

(2) The loss by radiation and conduction per square foot of outside surface of the furnace.

Solution:

(1) *Heat Evolved.*

	Lb. Calories,
90 per cent of 103,380	= 93,040
Heat Distribution.	
Heat in chimney gases	= 17,460
Heat in cooling water	= 9,000
Heat lost by radiation and conduction	= 66,580
Sum	= 93,040 (1)

(2) The outside surface consists of the top and bottom and sides. Their area is as follows:

	Sq. Feet.
Sides 18 × 3.14 × 19	= 1,074
Bottom 18 × 18 × 0.78	= 253
Top	= 253
Total	= 1,580

	Lb. Calories.
Loss by radiation and conduction	
Per 100 of ore	= 66,580
Per day	= 53,264,000
Per minute	= 37,000
Per square foot surface per minute $\frac{37,000}{1,580}$	= 23.4 (2)

It is interesting to note, as comparing this compact cylindrical furnace with the rectangular furnace of Problem 103, that although no fuel is used and cooling water is used, and radiation losses per square foot are greater because of thinner walls, yet the much smaller radiating surface more than counter-balanced these considerations, and permitted the furnace to run more economically.

Thick walls and minimum radiating surface are the requisites for economy of fuel in general, and the *sina qua non* for roasting copper sulphide ores by their own self-generated heat of oxidation.

Foundrymen's Convention.

At the convention of the American Foundrymen's Association, held in Philadelphia on May 21, 22 and 23, all records as to attendance were broken, since the number of those who registered was almost 1,400. Two notable features of the convention were the formation of the American Brass Founders' Association and the tribute paid by the foundrymen to their indefatigable secretary, Dr. Richard Moldenke, to whom they presented as a tangible expression of their admiration a silver punch bowl and a purse containing $1,200 in gold. The new president is Mr. Stanley G. Flagg, Jr., of Philadelphia.

On account of the great extent which the exhibits of foundry machinery and supplies had assumed—there being some seventy firms represented instead of forty at the last meeting—the convention was held in the Armory of the Second Regiment. Some of the most notable exhibits were the following: Universal molding machines, by Ph. Bonvillain and E. Roceray, of Paris; various applications of the thermit process and the production of pure metals free from carbon by the aluminothermic method, by the Goldschmidt Thermit Co., of New York (who distributed as a souvenir very pretty gold-plated scarf pins in form of their trademark, showing a thermit welding outfit); brazing apparatus of the American Ferrofix Brazing Co., of Philadelphia; melting furnaces of the Hawley Down Draft Furnace Co., of Chicago; the Monarch Engineering & Manufacturing Co., of Baltimore, and the Rockwell Engineering Co., of New York; industrial railway and accessories, by the Arthur Koppel Co., of New York; pressure blowers and fans by the B. F. Sturtevant Co., of Boston; pyrometers, by Edward Brown & Son, of Philadelphia; ferros and other alloys, by the Primos Chemical Co., of Primos, Pa.; conveying machinery, by the Link-Belt Co., of Philadelphia; graphite crucibles, by the Joseph Dixon Co., of Jersey City, and by R. B. Seidel, of Philadelphia; foundry supplies by the S. Obermayer Co., of Cincinnati, and the Whiting Foundry Co., of Harvey, Ill.; foundry ladles, cranes, furnaces and sundry foundry supplies, by the Northern Engineering Works, Detroit; by the New England Engineering & Equipment Co., Boston; by the J. W. Paxson Co., of Philadelphia; by the J. D. Smith Foundry Supply Co., of Cleveland, and the E. H. Mumford Co., of Philadelphia; ferro-alloys and refractories, by the Western Foundry Supply Co., of East St. Louis, Mo.; firebrick by Cyrus Borgner Co., of Philadelphia; graphites, sands and gravels, by Pettinos Bros., Bethlehem, Pa.; gluetrin core binder, by Robeson Process Co., of Camden, N. J., etc.

Abstracts of the papers presented at the convention will be given in our Synopsis after publication.

PHILADELPHIA MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

The sixth annual and eleventh general meeting of the American Electrochemical Society was called to order on Thursday, May 2, by President Carl Hering in the large lecture hall of the John Harrison Laboratory of Chemistry of the University of Pennsylvania.

Dr. Edgar F. Smith, the distinguished professor of chemistry at the University of Pennsylvania, referred, in his speech of welcome, to the fact that the first and second chemical societies of this country were founded in Philadelphia in connection with the University in 1792 and 1812. Again, the youngest chemical society, the American Electrochemical Society, held its inaugural meeting at the University in 1902. But the University has also held very close relations to electrochemistry through its professors. Dr. Smith referred to the early important work done by Robert Hare in electrochemistry and also to the long series of recent researches carried out under his own direction on electroanalysis.

CHARLES F. BURGESS,
President American Electrochemical Society.

Mr. Carl Hering, as president, thanked Dr. Smith and the University for the courteous welcome and hospitality.

Then followed the business meeting of the Society.

The annual reports of the board of directors, of the secretary and of the treasurer were presented. The financial status of the Society during the year 1906 was satisfactory in that the expenditures were brought within the receipts which, unfortunately, was not the case in 1905. On Dec. 31, 1906, there was a cash balance on hand of over $300.

The report of the tellers of the annual election was then read.

Prof. Charles F. Burgess, of the University of Wisconsin, is the new president; Prof. J. W. Richards, of Lehigh University, Bethlehem, Pa., is the new secretary, while Mr. P. G. Salom, of Philadelphia, Pa., was re-elected treasurer.

Messrs. C. E. Acker, Alfred H. Cowles and W. H. Walker were elected vice-presidents, Messrs. E. F. Roeber, S. S. Sadtler and L. Kahlenberg were elected managers.

Presidential Address.

Mr. Carl Hering then presented his presidential address, which dealt with the American Electrochemical Society itself, its past, present and particularly its future. He pointed out that modern societies are usually conducted by a few of their members—the chosen board of directors. Although it is impossible for a few to always please everybody, the history of the American Electrochemical Society has been free from any serious dissentions or factions.

Mr. Hering gave an outline of the work of the Society during the past five years. His account was illustrated by some interesting curves showing the fluctuations of attendance at meetings, size of volumes of transactions, number of papers presented at different meetings, growth of membership and finances. In general, the trend of the curves is toward the normal, showing that the wide fluctuations that are to be expected when a new society is started are lessening and things are apparently beginning to assume their natural levels. The three comparative curves in Fig. 1 show the growth of the older Bunsen Society in Germany of the American Electrochemical Society and of the younger Faraday Society in Great Britain. It will be seen that the American Electrochemical Society has grown more rapidly than either of the others and is nearly as large as its older sister society. Whether these rates will continue is mere conjecture, but if they do, our Society will, in the near future, be the largest of them all.

Dividing the annual expenditures by the number of members shows that what the Society has done for its members for the last five years has cost it $6.05 per member per year, and for this each member has paid only $5.00 dues. This apparent paradox is explained in part by the fact that the initiation fees have been used to pay part of the expenses—which is not good financiering—and partly by the fact that the Society has another source of income, namely, the sale of back numbers of *Transactions*. Nevertheless, the question of raising the dues has come up, but Mr. Hering thinks that if the management continues to exercise strict economy there is no immediate necessity to raise the dues.

The question has also been brought up of abandoning one meeting a year. But Mr. Hering advocates a mean between the plan of one meeting and the plan of two meetings. He proposes to let the large Spring meeting be the important one, and then hold a less pretentious and perhaps shorter meeting in the Fall in a central location like New York City, where there is a large local section and a large local membership. The last Autumn meeting in New York City was intended to be a test of this plan, but unfortunately it was encumbered by a number of mishaps which do not represent normal conditions.

The plan will, therefore, be tried again next Autumn, when another meeting will be held in New York City, and the large and active New York local section will assume the responsibility of its success. To omit one meeting entirely would, in Mr. Hering's opinion, be the beginning of the decadence of the Society, resulting ultimately in its absorption by some larger Society. By far the greater number of the members have joined for the sake of the *Transactions*, and many of these would, no doubt, be unwilling to pay the dues for only one volume. The *Transactions* are one of the chief attractions and assets of the Society and they should be guarded zealously.

The last part of the presidential address dealt with a proposition which seems of very considerable importance. It has been brought up recently in the form of a tentative proposition from the American Chemical Society, and originated by Dr. W. A. Noyes. Briefly stated, the two basic features of the proposition are, first, to combine into one monthly publication all papers on physical chemistry and electrochemistry read before either society, and, second, to reduce the cost of the publications of both societies by having the work done by one publication board. It is proposed, also, to combine the *Journal of Physical Chemistry* with this new joint publication.

Mr. Hering considers it needless to say that such a co-operation would be of great benefit to all concerned and is highly desirable. To have the work of publishing done by one board for both societies would naturally reduce the expenses

of both, as it avoids the duplication of expenses, gives both the advantages of cheaper rates and involves the principle that the cost of an additional amount of work is generally less in proportion. It therefore seems hardly necessary to dwell on the self-evident advantages of this feature, especially in the present era in which the combination of joint interests to reduce expenses is the prevailing practice.

The advantages of combining into one publication all papers on these two almost inseparable subjects, which are read before either society, and at the same time combining with it the *Journal of Physical Chemistry*, are also so self-evident that it seems hardly necessary to call attention to them. It is estimated that the amount of matter in it would probably be about double that of the American Electrochemical Society's *Transactions*. Not only would such a publication be of more value to those who get it than any of its constituents would be; not only would it bring together all the papers on the same general subject under one cover, but it would also avoid the duplication of the same paper in the different publications, it would give each paper a wider circulation, and would, in the future, facilitate the searches for published information on this general subject and making references thereto.

Mr. Hering thinks that if such a proposition is carried out it must be equitable to all concerned, neither party receiving any advantages at the expense of the other, and neither party assuming risks which the other should share. To be permanent the divisions of expenses for the future should not be based on present conditions. The individuality and the independence of the two societies should not be affected by such a joint publication of their papers.

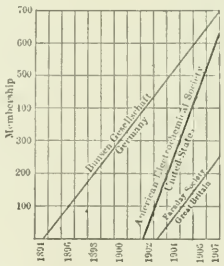


FIG. 1.—GROWTH OF ELECTROCHEMICAL SOCIETIES IN GERMANY, UNITED STATES AND ENGLAND.

Mr. Hering outlined a method of dividing the expenses between the two societies. The almost certain loss of some members who now belong to both societies is, in his opinion, the only feature on the other side of the balance sheet. There are now about 200 who belong to this class. This loss may perhaps be divided between the two societies but it is likely to fall almost entirely on the American Electrochemical Society.

In summing up his discussion of the proposition, Mr. Hering concluded "that such a combination of publications is of mutual advantage, is very desirable and should be accomplished if possible; that if entered into, it should be done with the view of permanency and not as an experiment, and that, therefore, the arrangements should be such that they will be as equitable in the future under changed conditions as they are to-day; that we should not thereby lose our independence or subject our papers to the censorship of any other society; and that it should not jeopardize the future existence of this society."

Contrary to ordinary practice, Mr. Hering's presidential address was open for discussion, which dealt with the proposed joining of publications.

Dr. Wilder D. Bancroft said that he agreed with Mr. Hering what ought to be done but not how it ought to be done. Mr. Hering's elaborate plan of dividing the expenses between the two societies would not work in practice, and he favored the other plan proposed by the American Chemical Society, that the American Electrochemical Society pay for each of its members a lump sum of $3.00 a year over to the Chemical Society, and let them do the work. He thought this plan was more convenient and perfectly safe. He thought the whole proposition an ideal one, since everybody would gain and nobody lose.

However, the sentiment of the members was by no means unanimous concerning the last point, as became evident from the remarks of some of the other speakers. Mr. Alois von Isakovics, the secretary of the New York Section of the Society, said that if the proposition went through we would certainly lose members. If the independence of the *Transactions* would be lost the Society itself would lose its individuality.

The new-elected president, Prof. Charles F. Burgess, spoke in the same sense. He expressed grave doubts whether the engineers—which are a large proportion of the membership of the American Electrochemical Society—would like such an arrangement. He thought such a step might seriously impair the usefulness and existence of the Society.

Mr. Charles J. Reed emphasized that no action on this important matter should be taken by the board of directors. The board of directors has the right to make definite arrangements only for one year and the Society at large must have the last word. If the two sub-committees appointed by the boards of directors of the two societies to consider the question should be able to agree on some plan, this plan to become effective should first be put to a mail vote so that all members of the Society may express their opinion. Mr. Sperry spoke in the same sense and a motion to that effect was carried.

Some Considerations on the Efficiency of Electrolytic Cells.

A paper on this subject was presented by Mr. W. R. Mott, who discussed the matter with the aid of various diagrams. Mr. Mott emphasized that the energy efficiency (watt-hour efficiency) is in most cases of practice more important than the current efficiency (ampere-hour efficiency). In the first case considered by the author the relation between voltage and current density (or current, since the dimensions of the cell are given) is represented by a straight line. In the second case the desired reaction does not start at low current densities, but only after the latter has reached a certain value; this is indicated by a sharp bent in the volt-ampere curve at that point. The third case considered by the author is like the second, but when the current density is further raised another new and undesirable reaction sets in; this is indicated by a second bent in the volt-ampere curve. In such a case it is necessary to work within the limits indicated by the two bents of the curve. For all three cases the watt-hour efficiency and ampere-hour efficiency curves were given, corresponding to the volt-ampere curves. Mr. Mott also pleaded for expressing the rate of chemical corrosion in terms of current density. His argument in this respect was as follows: He considered the deposition of a metal by electrolysis, and first assumed that nothing happens except the desired metal deposition. Then we have an ampere-hour efficiency of 100 per cent according to Faraday's law. But this is hardly ever obtained in practice, and Mr. Mott took into consideration one loss, namely, the redissolving of some of the deposited metal by purely chemical action. He also assumed that this chemical waste or corrosion is constant and independent of the current density. In this case the current consumed may be c, but part of it a is wasted, because the deposit corresponding to a, according to Faraday's law, is redissolved. Hence, only c-a represents the useful current and the ratio of c-a to c is the efficiency. In reality c and a were not considered as current by Mr. Mott, but as current density, and therefore given in amperes per unit area of active electrode. Just as the corrosion a in this case, Mr. Mott proposed to state any chemical corrosion in terms of current density.

The paper was briefly discussed by Dr. J. W. Richards.

Changes of Concentration and Migration Velocities.

A paper on this subject was presented by Mr. C. J. Reed. He attacked the statement that changes in concentration can be

caused by unequal migration velocities of oppositely charged ions. In his argument he assumes a cell with an electrode at each end and then considers any two arbitrary fixed planes within the electrolyte filling its whole cross-section. He shows that the space between these two arbitrary planes will always contain the same number of ions as at start, since the passage of both kinds of ions is the same through the two planes; hence the concentration in the space between these planes will remain constant. "Furthermore, it follows that since no changes in concentration could be produced in the body of an electrolyte by the inequality in the constant velocities of the oppositely moving ions, there would be as a result of such inequality accumulations of oppositely charged ions at the two electrodes which would be proportional to their velocities. This would be contrary to Faraday's law and contrary to the facts. The assumption of unequal constant velocities is, therefore, not only incompetent to explain changes in concentration, but it is in direct contradiction to the most thoroughly established facts of electrochemistry."

In the discussion Dr. Wilder D. Bancroft asked whether Mr. Reed denied the occurrence of concentration changes in electrolytic cells. Mr. Reed replied that his paper did not contain any such statement, but that he denied that concentration changes can be explained by different migration velocities. Dr. E. F. Roeber agreed that Mr. Reed's argument concerning the constancy of concentration within the space between his two arbitrary planes in the body of the electrolyte was sound, but he denied that Mr. Reed's argument applied at all to the two spaces between either of Mr. Reed's arbitrary planes and the electrode next to it. The concentration changes occur right next to the electrodes and are accounted for at that place by the theory. Mr. Reed replied that he could put his arbitrary planes wherever he chose, and that he therefore might move them right up to the electrodes.

Work Done in Electrolysis.

A paper on this subject was presented by Prof. J. W. Richards. The object of his research was to determine by a new experimental method the decomposition voltage of a solution, or the voltage which is necessary to set the products free at the electrodes from a given solution.

His method is essentially colorimetric. The experiments are arranged so that one can measure exactly the rise of temperature of the system during the electrolytic action. From this rise of temperature and from the specific heat one calculates the sensible heat evolved during the operation in calories.

At the same time one measures the volts, amperes and the time. This gives the total electrical energy which is put into the cell and which may be expressed in volt-ampere-seconds, or, its equivalent, calories.

This total electrical energy consumed in the cell is the sum of the sensible heat evolved and the chemical work done by the electric current. Hence the chemical work is determined by subtracting the sensible heat from the total energy. Since the latter two quantities were measured in calories, the chemical work is also found in calories and can then, of course, be easily converted into electrical energy units, namely, watt-seconds. The amperes and the time being known, the division of the watt-seconds by the ampere-seconds gives the voltage absorbed in the electrolytic action.

In this way Prof. Richards found that, as a first approximation, the voltage absorbed in setting free hydrogen and oxygen from a dilute sulphuric acid solution is 1.61 ± 0.06; he intends repeating the work with greater refinements so as to fix this datum with an accuracy of 0.01 volt, if the method can be so far improved.

Dr. Richards' paper was discussed at some length. Mr C. J Reed asked whether the heat taken away with the gases had been taken into account, and Dr. Richards replied that an approximate estimation showed this heat to be quite negligible. President Carl Hering then brought up the question whether the energy necessary for the expansion of gases at the electrodes comes from the consumed electrical energy. This is a disputed question, since it might just as well come from the heat of the surroundings. Dr. C. P. Steinmetz appeared to think that this energy is part of the electrical energy consumed. On the other hand, Mr. C. J. Reed pointed out that this is very questionable; for instance, in the electrolysis of an hydrochloric acid solution no chlorine gas is set free at first, but chlorine is evolved in solution and only after the solution is saturated with chlorine the latter is given off in form of free gas.

Prof. F. B. Crocker described some other methods of finding the decomposition voltage. One is to measure the total voltage and deduct from it the resistance drop which can be calculated from the dimensions of the cell and the conductivity of the electrolyte. This would give a check on Dr. Richards' method. Another method is to open the circuit after the current has passed through the cell and measure the counter e. m. f. Dr. C. P. Steinmetz suggested with respect to the latter method to take oscillographic curves of the e. m. f. while the current flows and when the circuit is broken. With respect to the scheme of determining the decomposition voltage from the polarization voltage, Mr. W. R. Mott remarked that condenser effects might disturb the results.

In his reply, Prof. Richards said that just on account of the practical disadvantages of the purely electrical methods he had devised this thermal method. Dr. H. E. Patten asked whether the method was really free from every hypothesis since it was tacidly assumed that there is a definite decomposition voltage.

Recent Developments in Electroanalysis.

What proved to be one of the most interesting papers presented at the convention was Dr. Edgar F. Smith's lecture on the series of researches on electroanalysis carried out under his direction at the University of Pennsylvania. It was an informal speech rather than a paper, but just for this reason it was most delightful as a human document, since it revealed the genial personality of the speaker. To sum up the underlying idea of all this work it may be said that all of it had to do with the application of a mercury cathode and a rotating anode for analytical work. The various apparatus and instruments developed for this purpose were exhibited during the lecture.

For the simplest experiments they used an apparatus which was a modification of a form first proposed by Gibbs, namely, a vessel with mercury in the bottom serving as cathode and a rotating inert anode above which produced agitation of the electrolyte. If copper sulphate is analyzed in this way the copper is taken out by the mercury cathode and after the completion of the experiment it is only necessary to siphon off the solution and weigh the amalgam. This gives the copper. Then titrate the liquid for the acid. This gives the SO_4. This method may be employed in a great many different ways and its application has resulted in enormously reducing the time required for an analysis. The latter is also made very much easier, since it is only necessary to see that the conditions are right and the electric current will do the work properly, swiftly and automatically.

In this way sulphates and chlorides may be analyzed, for instance, gold chloride, barium chloride, sodium chloride, etc. The apparatus for analysis of sodium chloride is especially interesting, since it is a modified Castner-Kellner mercury cathode cell in miniature. It becomes necessary in this case to prevent any action between the sodium amalgam and chlorine. The chlorine is absorbed by the revolving anode, which consists in this case of two silver discs, while the sodium alloys with the mercury and passes outward to the outer cell, on account of the agitation of the electrolyte. In the outer cell sodium hydroxide is produced, which is titrated. The silver anode has also proven successful in the analysis of sodium carbonate, the CO_2 being absorbed by the silver. The

apparatus consists simply of a crystallizing dish, the bottom of which is covered with mercury. Within this dish is placed a smaller bottomless beaker resting upon glass rods, so that there is free communication between the mercury inside and outside. The solution to be analyzed is placed above the mercury within the inner beaker, which contains the rotating silver anode. Water is placed above the mercury in the outer ring.

$K_4Fe(CN)_6$ and $K_3Fe(CN)_6$ can be analyzed in the same way, giving off their anions to the silver anode. In all these cases the anode is rotated at a speed of 150 to 200 r. p. m.

It is also easy to separate different constituents of a mixture of solutions by electroanalysis. For instance, from a mixture of $BaCl_2$, $CaCl_2$ and $MgCl_2$ it is easy to obtain the barium, calcium and magnesium separately by simply adjusting the voltage. The method is easy and quick.

For the electroanalysis of sodium fluoride a similar apparatus may be used as described above for the analysis of sodium chloride. But another anode must be used, namely, one which will absorb fluorine. A rotating lead anode is good, but best of all is an anode of calcium hydrate, that is platinum coated with calcium hydrate.

Dr Smith described some further achievements and also work which is now going on in his laboratory. The net result of all this work is that by the use of the electric current with a rotating anode and a mercury cathode many analyses have been rendered exceedingly easy and quick. Analyses which required formerly hours may now be finished in 15 minutes or so.

In the discussion, Dr. Bancroft remarked that it is no exaggeration to say that all important progress in electroanalysis in recent years has come from the Harrison Laboratory of Chemistry. Dr. Chandler also expressed his admiration for the "magnificent story" told by Dr. Smith. There was also some reference to Dr. Cushman's work on the electrolysis of feldspar. Mr. Hering suggested a spongy lead electrode, such as used in accumulators, for an anode to absorb SO_4 from a sulphate solution.

Pickling of Steel.

The paper on this subject was presented by Mr. Charles J. Reed, of Philadelphia. He dealt with a new method of removing an oxide scale from iron and steel by cathodic reduction. The method has already been described in the specifications of Mr. Reed's patents for the process (page 369 of our Vol. IV.). The iron sheets, rods or wire from which the oxide scale is to be removed are made cathode in an aqueous solution of sulphuric acid, preferably of specific gravity 1.20, having an acid content of 27 per cent, with a cathodic current density of $^1/_4$ to $^1/_2$ amp. per square inch, at a temperature of 60° C. Under these conditions the heavy scale on rolled iron rods is completely removed in from 2 to 3 minutes.

The chemical reaction is interesting, since it is not reduction of iron oxide to metallic iron (as might be supposed from the analogy with the apparently similar Salom process for lead reduction). As a matter of fact the oxide is reduced simply to a lower state of oxidation and dissolved, ferrous sulphate being produced. The solution of the lower oxide is effected without any of the metallic iron dissolving, as is the case in other processes.

The chief advantages of the process for commercial work are the short time required and the cheapness. As mentioned before the electrolytic process requires only about 3 minutes. Mr. Reed estimates that the process used on a large scale would save from 50 to 75 cents per ton. In the case of a single corporation this would amount to a saving of $3,000 a day.

Measurement of High Temperatures.

The first paper of the Friday session was presented by Dr. George K. Burgess, of the Bureau of Standards, Washington, D. C. The generally recognized temperature scale up to 1,200° C. is that of the gas thermometer. This scale is fixed by the determination of certain reference temperatures such as melting and boiling points and then preserved and distributed by means of pyrometers calibrated in terms of the temperatures of the fixed points.

The scale as defined by various gases is practically identical. Thus Jacquerod and Perrott, using N, air, CO, CO_2 and O at constant volume get values for the melting point of gold agreeing to better than 1°, and ranging about 1,067° C. Other determinations of the gold point are 1,064° C by Holborn and Day, using nitrogen at constant volume; and 1,065° C. by D. Berthelot by a method equivalent to the constant-pressure thermometer. We may say with considerable positiveness, therefore, that the temperature scale is known to within 3° up to 1,200° C.

There is no difficulty in reproducing the temperature scale by means of the fixed points as sufficiently pure metals may be purchased in the market. Some of these fixed points are the melting point of Sn 232.10, Zn 419.0, Sb 630.5, Cu 1084.1. With the exception of antimony the metals bought from different sources in this country gave practically the same melting points. For aluminium two "chemically pure" samples gave the melting point 655° and 650°, while aluminium from the Pittsburg Reduction Co. had a melting point of 658°.

Above 1,200° C. there is as yet no generally accepted temperature scale, and extrapolation in terms of some phenomenon varying with the temperature must be resorted to. Depending on the phenomenon used different values will be assigned to the fixed points that may be determined.

The author first considers the estimation of high temperatures by means of thermocouples. The usual type of thermocouple is a wire of 10 per cent rhodium or iridium alloy of platinum joined to a pure platinum wire. The relation between the e. m. f. E of such a thermocouple and the temperature t of its hot junction (when the cold junction is kept at 0° C.) in terms of the gas scale is usually given as $E = a + bt + ct^2$. This empirical relation is quite exact in the range from 300 to 1,200° C. By means of this relation determinations of melting points of platinum and palladium by the Bureau of Standards in Washington, the German Reichsanstalt and the British National Physical Laboratory have given very concordant results. The values found for the melting points of palladium are 1,535°, 1,535° and 1,530°, respectively, those for platinum, 1,710°, 1,710° and 1,706° C. Harker found by the same method the melting point of nickel to be 1,427° C.

Expressing results with the ordinary thermocouples in terms of Holman's formula $E = mt^n$, where m and n are constants, the palladium and platinum melting points become 1 543° and 1,731° C., respectively.

Other types of thermocouples give somewhat discordant results when interpreted in terms of these two formulæ. There is no particular extrapolation formula which holds generally for different types of thermocouples, so that there is very considerable uncertainty attached to the estimation of high temperatures by thermoelectric means alone.

The author then took up the discussion of radiation methods for measuring high temperatures. These methods are essentially based on one of two radiation laws, one being that of Wien for light of a single wave length or distinct color, the other being the Stefan-Boltzmann law for the total radiation.

Just as the thermodynamic scale of temperature is independent of the thermal properties of any particular substance, but would be exactly reproduced by an ideal gas, and is very nearly realized by the thermal properties of ordinary gases; similarly, the radiation scale of temperature is independent of the radiating properties of any particular substance, but would be exactly reproduced by the radiation from a "blackbody," and is very nearly realized by the radiation from an almost completely closed furnace at a uniform temperature. The radiation scale then may be and, in practice, is so defined as to be an extension of the thermodynamic scale. It is realized by measuring the intensity of radiation from an uniformly heated furnace of small aperture.

Any other substance than such an experimental black-body will have an apparent temperature, which is characteristic of the substance and kind of radiation, lower than its true temperature, when measured by radiation methods, because a black-body emits radiation of maximum intensity for any temperature. We call *black temperature* the temperature which a black-body would have to give radiation of the same intensity as that emitted by the substance under observation.

In Wien's equation there are two constants and their exact determination is of great importance for application of the formula. Thus, for the melting point of palladium the following three values were obtained in three different researches, 1,541° C., 1,582° and 1,546°; for the melting point of platinum, 1,746°, 1,789° and 1,753°, but the differences between the three values are mostly due to the difference in the value assumed for one of the constants in Wien's formula. More work must be done before the value of this constant is satisfactorily determined.

It is evident that the optical scale, however interpreted, gives temperatures considerably higher than does the extrapolation of either of the two thermoelectric relations given above. The following Table I. gives the corrections that should be added to thermoelectric determinations, making use of equation $E = a + bt + ct^2$ to give temperatures in terms of the optical scale as determined at the Bureau of Standards, which latter scale represents "true temperatures" with greater probability than does the thermoelectric extrapolation:

Table I.

Thermoelectric and Optical Scales.

Temp. on Thermoelectrical Scale	1200°	1300°	1400°	1500°	1600°	1700°
Optical-Thermoelectrical..	0	+ 2	6	14	25	43

It is also possible to make use of the intensity of radiation from the exposed surface of refractory material, as platinum, in order to measure its temperature, when the departure of the substance from ideal blackness has been determined. The relation between the black temperature using red light and the true temperature has been determined for platinum with considerable precision. The readings of an optical pyrometer sighted on a platinum strip may therefore be interpreted readily in terms of true temperatures. Use may be made of this principle to determine the melting points of substances in very minute quantities. As an example, the determination of the melting points of the metals of the iron group in an hydrogen atmosphere is given.

A platinum ribbon, heated electrically, is enclosed within a cylinder which may be filled with pure hydrogen. A very minute quantity—0.001 *mg* is sufficient—of the metal whose melting point is desired, is placed upon the platinum strip. The current is increased until the speck is seen to melt as observed with a microscope through a mica window. Simultaneously the temperature of the strip is measured by means of an optical pyrometer. The results obtained are given in Table II.

Table II.

Approximate Melting Points of Iron Group.

Metal.	*Purity.*	*Melting Point.*
Iron	99.95 per cent	1,507° C.
Chromium	98.99 "	1,482
Cobalt	99.05 "	1,464
Nickel	99.95 "	1,435
Manganese	98.99 "	1,207

The iron tested above is the electrolytic iron of C. F. Burgess. A pure oxide of metal may also be used in an atmosphere of hydrogen if the oxide is reducible by hydrogen. Thus cobalt from cobalt carbonate and nickel from nickel oxide gave melting points identical with those obtained with the metals. Dr. Burgess recommends the melting point of cobalt as a fixed point, since cobalt is cheap, oxidizes but little and has a sharply defined melting point (1,464° C.).

For higher temperatures than 1,800° C. our knowledge of the numerical values is still in the formative state. We are restricted here completely to the use of the radiation laws. At the Bureau of Standards in Washington the following method has given good results:

The metal is mounted as a filament in an incandescent lamp, and, by sending a current through, it may be adjusted to the same brightness as a carbon strip, also mounted in *vacuo*. The temperature of the carbon strip is given by an optical pyrometer. Using red, green and blue glasses before the metal filament its black temperatures may be determined as a function of the current. In this way the temperature current relation for the three colors, and thus the selective emission, may be very exactly determined up to 1,900° C.

In general, a substance has an apparently lower temperature for red than for green or blue light, as measured by an optical pyrometer with colored glasses before the eye. True temperatures are approximately obtained by adding to the temperature reading for blue light twice the difference between the red and blue temperature readings. Above 1,900° temperatures are estimated by extrapolation of the current temperature relation found to hold up to 1,900° C.

The melting point is found by increasing the current until the filament melts and noting the current at that instant. In this way the value of the black temperature, using red light of the wave length 0.66 μ, of the melting point of tantalum was found to be 2,742° C. from five determinations. This corresponds to a true temperature of the tantalum melting point of about 2,900° C. Similarly the melting point of tungsten was found to lie between 3,050° and 3,200° C.

The use of an electrically heated ribbon mounted in *vacuo* as a radiating source is very convenient for the calibration of optical pyrometers. With a tungsten ribbon to sight upon in place of the carbon, the direct comparison of optical pyrometers might be carried to very much higher temperatures than heretofore, and with a very small expenditure of energy and time. It does not seem improbable that in the near future, when an optical pyrometer is submitted to a standardizing laboratory for test at three points, it may be calibrated at the temperature of 1,000°, 2,000° and 3,000° C. in less than half an hour.

Finally, Dr. Burgess remarks concerning the Stefan-Boltzmann law for the total radiation that this radiation law has the most satisfactory theoretical basis, but has not been used to the extent that has Wien's law for the estimation of high temperatures. It appears to be much more difficult experimentally to get accurate results using the total radiation methods, or the Stefan-Boltzmann law, than when using the spectral radiation method or Wien's law.

In the discussion which followed Dr. Richards called attention to an error in the value of the melting point of tin given by Dr. Arndt on page 164 of our May issue. It is 232 not 241. This example shows how much confusion still exists with respect to "fixed points." In the use of optical pyrometers the occurrence of metallic vapors is very embarrassing.

Dr. Steinmetz doubted whether the melting point for chromium given in the paper was not too low. He had found the melting point of chromium free from carbon as made by an aluminothermic method to be very much higher. Dr. Richards suggested that a very small amount of aluminium might raise the apparent melting point.

Dr. Henry Noel Potter proposed to pass an inert gas over the melting substance, the temperature of which is to be measured immediately before making a measurement with the optical pyrometer, by this means the trouble due to metallic vapors can be overcome. Prof. S. A. Tucker stated that he also used this method and found it suitable.

Electric Conduction.

Dr. C. P. Steinmetz, of the General Electric Co., then delivered an experimental lecture at the special invitation of the board of directors of the Society. While the title was an-

nounced as "Electric Conduction Through Vapors and Gases" he proposed to discuss electric conduction in general.

When electric power flows through a circuit we observe phenomena outside and inside of the conductor. Outside we have electromagnetic and electrostatic stresses, inside we have conversion of electrical energy into heat.

Usually conductors are classified into three classes, metallic conductors, electrolytic conductors and gases and vapors. The best definition of metallic conductors can be given in a negative form; they are those in which energy is directly converted into no other form but heat. It is true that with a high-current density light is given off, but this light is really a temperature effect, and we have primarily a conversion of electrical energy into heat. The range of resistivity of metallic conductors is not very large. The resistivity is approximately constant but has generally a positive temperature coefficient. As an exception alloys may have a negative temperature coefficient.

Secondly, electrolytic conductors are characterized by the fact that the conduction is accompanied by chemical action. The resistivity is about 1,000,000 times higher than that of metallic conductors. The range of resistivity is quite large. They have generally a negative temperature coefficient.

Thirdly, gases and vapors have been the subject of much speculation, and in recent years the ionic theory which was invented to explain, or rather picture, the phenomena in electrolytes has been extended to picturing the phenomena of the electric conduction through gases and vapors. However, these are mere theoretical speculations—hypotheses which may be discarded in time; or as is now the practice in scientific circles, for the sake of continuity, hypotheses are not directly discarded, but amended and reamended until they become something quite different from what they were originally. Dr. Steinmetz proposed to deal only with experimental facts. There are so many sources of error in studying experimentally such phenomena, that he proposed to avoid another source of error, namely, speculation.

There are two distinct classes of conduction through gases or vapors. First, we have the electric discharge; second, we have the electric arc.

The characteristic feature of the electric discharge is that it takes place through the gas or vapor which existed between the two electrodes before the discharge started. The characteristic feature of the electric arc is that it takes place through a vapor which is produced by the arc itself and from the electrode metal. The arc is continuous, the discharge is discontinuous.

A Geissler tube discharge and a mercury arc were shown side by side in a tube which had several connections, high-tension alternating current being available for the discharge and direct current for the arc. The difference between the appearance of the discharge and the arc was very striking. The discharge had an apparently faint luminosity and showed decided striations.

Concerning the nature of the electric discharge much speculation has been produced but very little actual facts are known. More is known concerning the arc. Since in the arc a vapor acts as conductor which is produced by the arc itself and from electrode material, the fundamental question arises as to the nature of the vapor; that is, which of the two electrodes yields the vapor.

This question can be answered by studying the spectrum of the vapor or simply by looking at the appearance of the arc when changing one of the electrodes.

With a positive magnetite electrode and a negative carbon electrode we have the familiar carbon arc. With a negative magnetite electrode and a positive carbon electrode we have the brilliant magnetite arc (iron and titanium spectrum). With a negative magnetite electrode and a positive copper electrode we have the same magnetite arc. This shows that the material which produces the vapor comes from the negative electrode.

For this reason an alternating current cannot maintain an arc in general, since at each reversal of the current the negative electrode stops giving off the vapor, which allows the arc to pass, so that at each reversal it becomes again necessary to start the arc. Only under such special conditions in which an alternating current is able to start an arc again at each reversal an alternating arc becomes possible. This is for instance the case with carbon. Dr. Steinmetz discussed the special conditions which must be fulfilled for an alternating-current arc.

By using a third electrode Dr. Steinmetz showed another phenomenon which is a consequence of the fact that the conducting vapor comes from the negative electrode. He showed that he could shift from positive to positive but not from negative to negative. In connection with these experiments the rectifying effect of an arc was discussed.

Dr. Steinmetz developed the power equation of an arc which states that the e. m. f. multiplied by the current is equal to the circumference of the arc multiplied by the length of the arc and multiplied by the square root of the current. From this it follows directly that the voltage consumed by the arc in the vapor is proportional to the arc length and the arc circumference, and inversely proportional to the square root of the current. There is also a potential drop right at the electrodes.

In the concluding part of his address Dr. Steinmetz pointed out the difficulties in classifying various phenomena in a field of investigation. Thus it is possible to classify conductors into metallic conductors, electrolytic conductors, insulators and arc conductors according to their temperature-resistance curves, but such a classification does not work out right. There are always some materials which do not fit into the classification. The same material may show different characteristics under different conditions. Thus, amorphous carbon has a negative temperature coefficient, but when it is heated to a sufficiently high temperature it assumes a positive temperature coefficient and has for that reason been called metalized carbon.

A whole class of conductors which do not fit into such a classification according to the temperature coefficient characteristics is what Dr. Steinmetz calls the pyro-electric conductors. An example is metallic silicon. According to the range of temperature at which they are used such pyro-electric conductors may show all the different characteristic features of metallic, electrolytic or arc conductors. In general, compounds of the form M^{II}, $M^{IV}O_2$, are pyro-electric conductors.

While we speak of classification and of the classes of electrolytic conduction, metallic conduction, etc., we should rather speak of them as types of conduction. The most interesting results should be expected from an investigation, not of the typical cases but of bodies laying on the border line.

Electrodeposition of Zinc.

A paper by Ralph C. Snowdon on this subject was presented in abstract by Prof. W. D. Bancroft. It related to an experimental investigation of the conditions affecting the quality of electrolytically deposited zinc. The variables taken into account were concentration, degree of acidity and alkalinity, reducing agent, current density and temperature. The cathode was rotated in every case and it was first thought that differences in speed would be of minor importance provided a fairly high rate of speed was maintained, but this was found to be a delusion. As a matter of fact the limiting current density at which the deposit begins to become bad depends more on the rate of stirring than on all the other factors combined. The general results of the papers were summed up as follows:

Good deposits of zinc may be obtained from acid or alkaline solutions, even at such high current densities as 60 amps. per square decimeter. The rate of rotation of the cathode has an enormous effect on the upper limit of the current density.

Since zinc will precipitate readily from strongly alkaline solutions, the resistance of these solutions, and consequently the voltage across the terminals, can be made very low for any

given current density. A high current efficiency may be obtained in alkaline solutions.

More finely crystalline deposits are obtained from alkaline than from acid solutions. Increasing temperature or concentration increases the size of the crystals. Presence of formaldehyde decreases the size of the crystals. Increasing the current density decreases the size of the crystals.

A Practical Limitation of Resistance Furnaces—The Pinch Phenomenon.

A very interesting paper on this subject was presented by the president, Mr. Carl Hering. In theory, the electrical resistance furnace is a very simple apparatus; electrical energy is converted into heat in the resistance material with a conversion efficiency of 100 per cent. Theoretically, it might be argued that the only limitations to the temperature are the volatilization of the resistor itself, and in the case of liquid resistors the inability to get a retaining cell or trough which does not itself melt. However, there are other limitations. The one described in Mr. Hering's paper applies to that type of resistance furnace in which the material to be treated forms the resistor, in the form of a column of liquid in a trough, as distinguished from that type in which the resistor is a foreign body like graphite of platinum, which is surrounded or enclosed

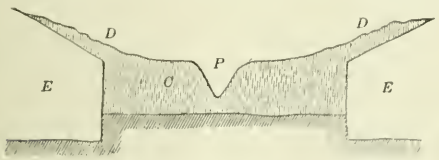


Fig. 2.—Pinch phenomenon.

by the materials to be treated. Of these two classes of furnaces the latter is by far the simpler in theory, in practice and in operation. Innumerable difficulties encountered in the former are overcome in the latter, and it is probably a good rule to use the latter whenever possible in preference to the former.

It would be wrong to argue that by simply increasing the watts per cubic inch in a furnace, any desired high temperature may be reached up to that of volatilization, which means a destruction of the resistor. This would be wrong, since the pinch phenomenon, which is the subject of Mr. Hering's discussion, may set a much earlier limit. The phenomenon is as follows:

When the current density in a liquid conductor in an open channel is increased sufficiently, the conductor will be found to contract in cross-section with considerable force, especially at a place where there is some slight obstruction in the channel, or where, for any other reason, the cross-section is less than the average. This contraction resembles the depression in plastic material that has been pinched between the fingers; as the column of liquid looks as though it were being pinched by some mysterious and invisible force, the writer termed it the "pinch phenomenon," for want of a better name.

In Fig. 2 *E E* are the cold electrodes of such a furnace; *C* is the column of liquid conductor, which acts as the resistor, and *P* is one of these pinched contractions. The liquid on both sides of the contraction slopes like the letter V, with inclinations of 45° and over. "The liquid will stay in this position, thus forming a stable state. The inclined surfaces of the liquid, though smooth, showed signs of great internal agitation, as though the liquid was continually running down hill, but was being as rapidly forced up hill again. It was a somewhat curious and interesting sight to see the surface of a liquid sloping at a steep angle and yet be in a stable state. The first impression was that a large leak had suddenly formed, and that the molten metal was rapidly flowing down and out through it; but it was soon found that the condition was a stable one."

When, under these circumstances, the current density is still further increased, this V-shaped depression becomes deeper and deeper until it finally reaches the bottom of the channel; this, of course, breaks the circuit and the liquids then immediately flow together, only to be instantly parted again, thus forming a violent automatic interruptor of the current, accompanied by a sputtering of the metal, loud crackling sounds, and, incidentally, by the great disgust of the man who is running the furnace, as it means that the limit has been exceeded, and if the circuit is not opened at once at the switch, to allow the parted liquids to flow together again to their normal level, there is a strong likelihood that the reduction of the current will cause the core to freeze in this parted condition, which gives rise to serious difficulties in mending the break so that it will carry current again.

If there is any dirt, infusible material or pasty, poorly-conducting slag floating on the surface of the liquid, it will naturally fall into this cavity, and as the conductor in the narrow neck is apt to volatilize, owing to the high current density, while the rest of it is apt to freeze, owing to the reduction of the current, the result is that a complete break is apt to form, through which it may be very difficult and sometimes impossible to start the current again, thus requiring a dismantling and reconstruction of the furnace. It is obvious that this phenomenon places a limit to the current, which can be passed through a liquid resistor of given cross-section, thereby limiting the temperature which can be obtained. This limit may be far below that desired, thus completely defeating the purpose of the furnace. It, therefore, is an important factor to be taken into consideration by the designers of this class of furnace. What the limit of temperature will be, will depend, of course, on the particular circumstances; it is evidently not possible to give any fixed rule. It may, perhaps, be subjected to calculation, but this is doubtful, as this local pinching seems to be originally induced by some obstacle or contraction in the channel, which, being generally accidental, is not within the reach of mathematics.

One of the experiments made by Dr. Northrup, at the author's suggestion, has shown that if the channel is quite uniform, the contraction in cross-section will also be uniform over its whole length, that is, the level of the liquid will lower uniformly, and, therefore, the danger of parting will not be so great. This explains the observation made by the writer that in a furnace of this type, the liquid conductor kept creeping up on top of the cold electrodes, as at *D D* in the illustration, piling itself up in large quantities and solidifying after it got there. Fresh material had to be added for some time to keep up the level, until the stable conditions were finally reached. This stable condition is different for each current.

To avoid the pinch phenomenon, the channel should be made as perfectly uniform as possible and kept free from obstructions. Further, both depth and width should be made large, which means short channels, low voltages, enormous currents, or else a large capacity of the furnace. In other words, the danger from this source is greatly increased as the furnace becomes smaller in capacity. Some idea of the strength of this contracting force may be had from a case in the writer's experience, in which the V-shaped depression extended down as much as 6 inches through molten iron to the bottom of the channel, causing a complete rupture followed by freezing, which necessitated the dismantling of the furnace.

The phenomenon has been studied and its theory been developed by Dr. E. F. Northrup, who has made use of it for the construction of simple forms of measuring instruments like those of the indicating and integrating types that measure direct and alternating currents equally well, since the phenomenon is independent of the direction of the current and takes place with either direct or alternating current.

The action may be explained according to Dr. Northrup from the principle that currents flowing in a like direction attract each other, hence all the linear current elements in a con-

...or are attracted to its center, causing a contraction. On the other hand, Mr. Hering considers the pinch phenomenon to be due to some action of the ever-present encircling magnetic lines of force which are all under tension like stretched rubber bands, and therefore exert a radial pressure on the material which carries the current.

In the discussion which followed, Mr. Reed remarked that he had observed this phenomenon with mercury in 1895, when he observed a breakage of a mercury column and a vortex. Dr Henry Noel Potter thought that the phenomenon would probably manifest itself in induction furnaces, and in view of the uniform cross-section of the furnace he asked at what place the pinch effect would occur. Mr. Hering answered that it would be most liable to occur wherever there was a little obstruction or irregularity.

The Action of Carbon on Magnesia at High Temperatures

A paper by Dr. O. P. Watts on this subject was read in abstract, in the absence of the author, by Prof. C. F. Burgess. In building a resistance furnace, magnesite brick was used for lining and a carbon resistor. The author observed a pitting of the magnesite and the condensation of something that was apparently lamp black. In another case magnesite tubes were baked in carbon. The magnesite tubes disappeared completely, leaving a groove where they had rested in the carbon. Dr. Watts believes that we have to do in this case not with the formation of a compound, but with a physical mixture of MgO and carbon. He could produce a similar substance synthetically by grinding in a ball-mill and mixing. Prof. Burgess was not quite sure whether a compound was not really formed. The paper was discussed by Messrs. Richards, Reed, Bancroft, Potter and Burgess.

Influence of Stress on the Corrosion of Iron.

Dr. W. H. Walker, of the Massachusetts Institute of Technology, presented a paper on a very extended experimental investigation of the influence of stress on the electrolytic corrosion of iron and steel. Without his curves and tables it is impossible to give a full account of the paper but we hope to publish a summary of the chief results in one of our next issues. It may be stated here that the method consisted in measuring the electromotive force in the electrolytic corrosion of different samples of steel under different conditions of stress. Corrections were made for changes of temperature. Dr. Walker investigated the extent to which the e. m. f. is influenced by the stress. One of his results is that as a material adapts itself to the stress the e. m. f. returns to its normal value, so that there is no danger of stresses unduly increasing the corrosion of steel structures.

Polarization Voltages of Silver Nitrate Solutions.

The first paper of the Saturday session related to an investigation of the polarization voltages of silver nitrate solutions by Messrs. J. A. Wilkinson and H. W. Gillette. In the absence of the authors it was read in abstract by Prof. Bancroft. Instead of measuring the decomposition voltage the authors measured the polarization voltage, or counter e. m. f. given by the cell after it had been polarized by a charging current. Four variables were considered: temperature, silver nitrate, acid and water. They let each one of these vary by itself, keeping the other three constant. The chief results of the investigation are summed up as follows:

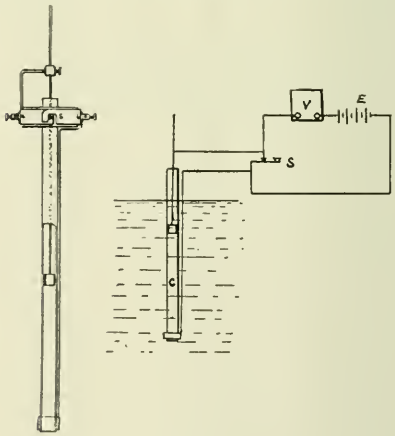
The polarization voltage of acidified silver nitrate solutions may be made to vary from 0.625 volts to 1.05 volts. It varies with variations of temperature, silver nitrate, nitric acid and water.

The temperature coefficient is approximately 0.8 millivolts per degree over a fair range of compositions and temperatures. A decrease in the concentration of silver nitrate increases the polarization voltage if the concentration of nitric acid be kept constant. A decrease in the concentration of nitric acid decreases the polarization voltage if the concentration of silver nitrate be kept constant. The polarization voltage decreases if the concentration of silver nitrate and nitric acid are decreased in the same ratio.

When measured against a sulphuric acid, mercurous sulphate, mercury electrode, the potential difference between silver and the electrolyte is decreased slightly by the addition of nitric acid, while the potential difference between peroxide and electrolyte is apparently increased a great deal. The abnormal result with the silver electrode may be due to a change in the potential difference between the solutions. There is nothing in the data obtained to show whether or when the product formed at the anode changes from peroxide to oxygen.

Rapid Measurement of Electrolytic Resistance.

A paper on this subject was presented by Prof. C. F. Burgess, of the University of Wisconsin. The specific resistance of an electrolyte varies in a marked degree with variations in concentration, temperature and purity. Notwithstanding this fact, comparatively little use of resistance seems to be made in the handling of solutions in technical operations. An increase in the amount of various acids and salts in aqueous solutions from 5 parts to 10 parts per hundred produces a decrease of approximately 50 per cent in the specific resistance, while the



Figs. 3 and 4.—Apparatus for Measuring Electrolytic Resistance.

corresponding variation in the specific gravity is in the neighborhood of 3 per cent. The sensitiveness, therefore, of a resistance measurement as a means of determining the strength of a solution is materially greater than that of a density determination. The degree with which water approaches purity may be more readily judged by a resistance measurement than by a measurement of its specific gravity.

In technical works, where solutions are handled, the control is usually effected by the use of the hydrometer and by chemical analysis. Devices for the determination of specific resistance are scarcely known outside of the laboratory, though the sensitiveness and range of its measurements are greater than those obtained by the hydrometer. Resistance measurements, correctly interpreted, may, in many cases, enable chemical analysis to be dispensed with. Even in electrochemical work, where the specific resistance has a practical significance, other than in throwing light upon the composition of solution, little use is made of this measurement. The electroplater makes daily use of his hydrometer, but knows the "resistometer," if it may be so called, only as a laboratory instrument.

The reason why no use has been made in the past of such methods of industrial work was probably that no simple appa-

ratus was available for this purpose. Prof. Burgess describes a method which has been in use for several years at the University of Wisconsin, and by the use of which the time and trouble required for taking a reading is little greater than that needed for determining the temperature by means of a thermometer, or the specific gravity by a hydrometer.

No new principles are involved in this method, which is based upon the fact that a resistance placed in series with a voltmeter and a source of electrical pressure decreases the voltmeter reading. The apparatus required consists of a glass tube with suitable electrodes, as shown in Fig. 3, a voltmeter of the ordinary type, and a source of constant electrical pressure, such as may be cheaply and conveniently furnished by a few dry cells connected in series. The electrode tube, as illustrated in Fig. 3, consists of a glass tube, with its upper end passing through a square ebonite block. Upon this block are mounted the two binding posts, one of which makes connection to an adjustable electrode placed inside of the tube, and the other to a fixed electrode placed outside of the tube near the bottom. The two terminals are kept normally short-circuited by means of the spring *s*, and this contact may be broken by pressure of the fingers applied at the points *a* and *b*.

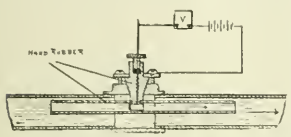


FIG. 5.—TEST OF SOLUTION FLOWING THROUGH A PIPE.

The operation of the measurement consists in connecting the tube terminals through a voltmeter to a source of constant pressure, as shown diagramatically in Fig. 4. The tube is dipped into the electrolyte so that both electrodes are immersed. The electrodes being normally short-circuited by the switch *s*, the column of electrolyte *c* is placed in series with the voltmeter and, consequently, decreases the voltmeter reading.

The resistance of the column of electrolyte *c* is equal to R′ multiplied by the ratio of E — E′ to E′, where R′ is the resistance of the voltmeter, E is the total pressure measured with the switch closed, and E′ is the reading of the voltmeter with the switch open. The specific resistance may be derived from this value by knowing the dimensions of the column of electrolyte or by calibrating the instrument with a standard solution.

With the electrodes fixed at a certain distance apart, and with an unvarying source of pressure, a voltmeter may be calibrated so as to indicate directly the specific resistance.

There is an advantage in the fact that the column of electrolyte is at the same temperature as the main body of the liquid; and the instantaneous flow of current, which is necessary in taking the voltmeter reading, cannot heat the electrolyte to an amount sufficient to cause appreciable variation of temperature.

The resistance of the voltmeter should be accurately known and the latter should preferably be of high resistance type. For the highest degree of sensitiveness the dimensions of the column of electrolyte should be adjusted so as to be somewhere near equal to the resistance of the voltmeter. For a tube from 0.5 to 1 centimeter in diameter and about 20 centimeters long, a voltmeter reading from 6 to 10 volts should be suitable when measuring electrolytes of high conductivity.

Care must be taken to avoid polarization between the electrodes. For this reason copper electrodes should be used in copper solutions, etc. Further, the higher the voltage the less is the percentage of error possible by polarization.

Where a record is desired on a solution flowing through a pipe, it may be obtained in the manner illustrated in Fig. 5, where a hard rubber tube within the metal pipe carrying the liquid has a branch which projects through the walls of the pipe, and which carries the wire leading to the electrode. The pipe thus serves as one of the electrodes, the columns of electrolyte, either side of the inner electrode being in parallel.

It is evident that this method of measurement lends itself readily to the use of a recording voltmeter.

In the discussion which followed, Mr. Carl Hering suggested that the apparatus might be used for a substitution method, but Prof. Burgess said that his object was to avoid such a method and to make the measurement as simple as possible. The calculation which is required is also very simple.

ENERGY CHANGES ACCOMPANYING ABSORPTION.

Dr. HARRISON E. PATTEN, of the Department of Soils, of Washington, D. C., presented a paper on this subject. The term "absorption" is used in general to designate the process by which a solid or a liquid draws unto itself and retains within its structure, or on its surface, another solid, liquid or gas. Where a solid retains another substance so that the two form a homogeneous body, the mixture is either a definite chemical compound or a solid solution.

A special case of absorption has been termed "adsorption," which may be defined as the existence of a difference in concentration or density of the film adjacent to a bounding solid, and the concentration or density of the mass of the liquid or gas which bathes this solid.

Whether this absorbed film is in a liquid, solid or gaseous state, or even loosely combined with the solid bounding medium, is not easily determined, and has been the subject of much discussion. The change of state from solid to liquid and liquid to vapor is in general very gradual. All the recent physical researches dealing even with hard polished "solid" surfaces, indicate a mobility of parts, an openness of structure and a high power of retaining foreign material. But the ability of one body to hold another upon its surface is dependent upon the material of which each consists. Consequently, we are accustomed to say that adsorption depends upon the chemical constitution of the solid and of the substance. Another way of stating the same idea is to attribute adsorption to a specific attraction between solid and adsorbed material. It is possible, too, to view absorption as a special case of adsorption, in that where a solid imbibes a solution or a gas, we have an adsorption upon the walls of the fine pores in the solid, as well as a filling of these pores by the liquid or the gas. The first four paragraphs below define more precisely four cases where purely adsorption effects may be expected, and the next three paragraphs indicate the extension of these adsorption phenomena to include cases more commonly considered absorption effects.

1. The simplest case is where a plane surface, such as glass, adsorbs a vapor or a dye from its solution. Here a regular distribution of adsorbed material between solid and solution can be shown.

2. When the surface of the solid is curved the radius of curvature must be taken account of in discussing the effect of surface tension upon the change of concentration near this surface, and for surfaces not spherical the treatment becomes still more complicated as the radius of curvature varies.

3. When the surface incloses a sphere or other form of cell, adsorption is still in evidence upon the inside wall of the cell.

4. Conversely, a sphere or other solid body exhibits adsorption and the curvature of its surface must be considered.

5. Where a solution is taken up by a solid made up of cells, the total abstraction of solute from the main body of solution is produced by adsorption added to the simple filling of the cells with solution.

6. Crystalloids as well as amorphous bodies can imbibe liquid and swell.

7. Consequently, a solid solution may be taken as the limiting case of imbibition plus adsorption.

The author then discussed critically various formulas which have been proposed for calculating adsorption and reviewed the work done in this field during recent years. The concluding part of the paper is a summary of recent work in this field as follows:

Our knowledge concerning the energy changes accompany-

The discussion was then summarized by Dr. Patten as follows:

Porous bodies absorb gases, even those most inert chemically. Plane surfaces of solids show the same power of retaining gases. The degree of absorption varies with the form and size of the pores; in general, the greater the surface the greater the absorption.

Different substances possess a different absorption capacity. The same substance absorbs different quantities of different gases. Solids exercise a selective absorption toward mixed gases; mixtures of solids absorb a gas additively. Easily condensed gases are in general absorbed more easily.

Heat is evolved during the process of absorption, but this heat is greatly in excess of that given out by the condensation of the vapor to liquid.

At higher temperatures absorption is very considerably decreased. Absorbed gases are held with remarkable tenacity; hygroscopic water is completely removed from glass and mineral surfaces only at temperatures ranging from 500° C. to 800° C. Thus the water is present under its vapor pressure, which at these high temperatures amounts to hundreds of atmospheres, and it is seen why pressure changes within one atmosphere are of little effect upon the absorption, while the initial layer is being adsorbed. The portions of gas absorbed later are held less strongly and are under lower vapor pressure; and for them, the quantity of gas absorbed increases with the vapor pressure, but not according to a simple mathematical formula, although several have been proposed.

The adsorption of gases upon solids is not due to the solution of gas in a moisture layer on the solid, as is shown by the adsorption of gas by bodies which have been heated to redness and cooled in a vacuum. The absorption of gases by solids has recently been shown to render uncertain all of the attempts to measure the temperature of a flame by immersing in it a solid and determining the temperature of the solid. Porcelain and platinum may differ from each other by 400° C. while in the same flame.

The heat evolved upon wetting a powder with liquid is not influenced by the relative quantity of liquid added beyond the certain minimum volume of liquid required to produce the maximum heat effect. The finer the powder the greater heat effect for the same solvent. The heat evolved is different for the same substance wet with different liquids. Soils show a temperature rise upon addition of water of 5° to 8° C.

A powder in equilibrium with vapor at a given temperature and pressure can retain practically as much condensed vapor adsorbed on its surface as when kept below the liquid water at the same temperature and pressure.

In many instances a substance, such as starch, imbibes a liquid and swells. Here we have both imbibition and adsorption, and the heat evolved is, as we should expect, greater than for simple imbibition, and less than that observed where adsorption is the main effect.

When a gas is absorbed by a metal many interesting physical changes in the metal may be effected. Its volume, hardness, elasticity, electrical conductivity and single potential and rate of solution in various solvent liquids are changed. The absorption of a gas, too, may depend upon its condition; that is to say, the energy it possesses. For example, free hydrogen gas is very slightly absorbed by iron and some other metals, but hydrogen freshly liberated from combination either by electrolysis or by action of metal upon acid is very strongly absorbed by the iron. Palladium, on the other hand, absorbs free hydrogen with great avidity.

Radium gives off radiant energy which causes paper to absorb nitrogen and oxygen. Radium emanation is absorbed by charcoal. The paper was discussed by Prof. Bancroft and Prof. Richards.

Electric Reduction of Titaniferous Iron Ores.

A paper on this subject by Mr. Gustave Gin, of Paris, was then presented. The author referred to the abundance of titaniferous iron ores in many places. They are not used at present, since it seems that troubles have been experienced in attempts of blast furnace men on account of difficultly fusible titaniferous slags resulting from treatment of such ores in the blast furnace.

It is possible that this difficult fusibility of titaniferous slags is caused by an improper calculation of the charge of the furnace. To form a uni-silicate calcium slag requires approximately as much lime as there is silica to be fluxed, but a uni-titanate calcium slag requires only two-thirds as much lime as titanic acid fluxed. It is possible that too much flux is ordinarily used when titanic acid is present with silica in the furnace. Whether this be the fact or not there is no difficulty in fusing silico-titanate calcium slags in electric furnaces.

In 1901, Mr. Gin treated in an electric furnace titaniferous iron ore from Norway of the following composition:

Fe^2O^4	55.73 per cent	Fe = 53.76 per cent
Fe^2O^3	3.16 "	TiO^2 = 10.40 "
$TiFeO^3$	30.90 "	
Si^2O^3	0.56 "	
Al^2O^3	3.01 "	
Not determined.	3.01 "	

The charge was composed of 100 kilograms of ore, 15 limestone, 25 coke, and 274 kilograms was treated in 4 hours, using 280 kilowatt-hours of electric energy, and yielding 102 kilos of metal of the following composition: 94.00 per cent iron, 3.10 carbon, 0.86 silicon, 0.10 titanium, 0.06 phosphorus, 1.28 not determined. The slag had the following composition: 32.50 per cent TiO^2, 20.80 SiO^2, 4.10 Al^2O^3, 8.10 FeO, 32.70 CaO, 1.80 not determined.

The electric energy amounted to 2,850 kilowatt-hours per ton of pig iron. In a larger improved furnace this figure would be certainly not over 2,280 kilowatt-hours.

The above test was made at the French works while the following experiment was made in a German institute of Technology.

Sandy iron concentrate from Java was mixed with limestone and carbon in the proper proportions, and submitted in a resistance electric furnace to a direct current of about 500 amps., at a working tension of 60 to 65 volts. The charge was easily melted; at the end of an hour's running the temperature of the melted mass, taken by a Wanner pyrometer, was a little over 1,900° C. The slag and metal were then cast, the metal in a previously heated crucible; the slag was very fluid and ran easily from the furnace. The clean ingot of metal weighed 42.62 kilos. The slag was black, with glassy lustre.

The analysis of materials and products were as follows:

	Per Cent.
Ore.	
FeO	28.50
Fe^2O^3	49.95
MnO	0.98
CaO	0.37
MgO	2.35
TiO^2	16.60
SiO^2	1.60
Etc.	0.25
Metal.	
Fe	94.94
Mn	1.52
C	3.05
Si	0.37
P	0.11
S	0.01
Ti	Trace
Slag.	
SiO^2	8.90
TiO^2	38.72
Al^2O^3	5.18
FeO	10.03
CaO	34.80
Etc.	2.37

The pig iron was very low in sulphur, while the phosphorous it contained came mostly from the carbon used for reduction.

The conclusion drawn from these experiments is that the reduction of titaniferous iron ores in the electric furnace presents no special difficulties, and that pure iron can be obtained commercially therefrom in regions where the ore is near abundant and cheap water power.

In briefly discussing the paper Dr. Richards pointed out the importance of this subject for Canada.

ELECTRIC TUBE FURNACE FOR TEMPERATURE MEASUREMENTS.

Prof. SAMUEL A. TUCKER, of Columbia University, presented a paper in which he pointed out that the measurements of the higher temperatures in the electric furnace is one of considerable difficulty, and this is due for the most part to the presence of fumes derived from the volatile constituents present which obscures the readings of the optical pyrometer.

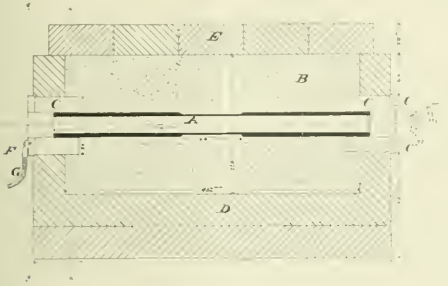


FIG. 6.—ELECTRIC TUBE FURNACE.

In order to eliminate this trouble, Prof. Tucker devised the furnace shown in side elevation in Fig. 6. The current passes through the carbon tube to be heated so that the nature of this material is of great importance. Agglomerated carbon tubes are now made by the National Carbon Co., of Cleveland, and they were found to meet the requirements. The only change in the dimensions made was in turning off a portion in the middle for a distance of about 9 cm., so that the heat is concentrated at this portion of the tube.

A greater difficulty is to find the proper material to surround the tube. It must have a high electrical resistance, it must be very refractory so as to withstand the high temperature, and it must be free from impurities so that no fumes will be evolved on heating. Petroleum coke was found to be the most practical. It is a very pure form of carbon, and is a relatively poor conductor of electricity, and although there is some loss of both heat and electrical energy it does not seem to be excessive.

Two methods were used to unite the carbon tube A to the water-cooled brass holders C. The ends of the tube were copper plated and then soft soldered into the holders, or what appears to be equally good is to pack thin sheet copper or gauze between the tube and the holder. With solder it means dismantling the furnace pretty well when it becomes necessary to put in a new tube, but the soldered joint makes a very sure electrical connection.

The water-cooled holders are of brass, the joints of which are soldered. The end plate of these holders is made heavy to admit of fastening the lugs F by the machine screws. It would be better to braze the joints of this holder, which would make it possible to soft solder in the coppered ends of the carbon tube with ease, so that there would be no danger of starting a leak in the holder

From the drawing it will be seen that the carbon tube has a total length of 54 cm., an outside diameter of 38 mm., except for the middle portion, where it is reduced to 31 mm., the inside diameter being 25 mm.

The fire-brick enclosure is 575 mm. x 380 mm., the opening 402 mm. long by 235 mm. wide. This opening is filled with petroleum coke B.

The furnace is covered with carbon or other refractory bricks E. Water is circulated through the holders C by the inlet C'' and outlet C'.

For temperature measurements it is only necessary to place a small graphite boat with a disc at one end to fit the internal diameter of the tube in the middle portion of the tube. The boat will be raised to the temperature of the portion of the tube in which it is placed, and its temperature taken with the optical pyrometer sighted through the end of the tube.

For the determination of the melting points of minerals, refractories, etc., the disc has a small hole bored in it which is covered by the material to be melted. A second observer can then look at the disc through a red glass, and as soon as the hole appears in the disc the temperature is taken. With the pyrometer at one end and the observer at the other end of the tube a close determination of the melting point can be made.

With this furnace, Prof. Tucker was able to obtain the following temperatures with alternating current. With a current of 330 amps. at 6 to 8 volts a temperature of 1,200° C. was reached within 4 minutes, with a current of 600 amps. at 15 volts the temperature was 1,800° after 11 minutes. With a current of 850 amps. at 15 volts the temperature was 2,952° C after 14 minutes.

GRANULAR CARBON RESISTANCE FURNACE.

A second paper presented by Prof. SAMUEL A. TUCKER dealt with the construction of a furnace using a resistor of granular carbon which is particularly serviceable in laboratory work. The following description applies to a furnace of maximum capacity of 30 to 35 kw.

As shown in the Figs. 7 and 8 the granular resistor A is retained by the magnesia brick F at the sides and the bottom. The electrodes C of Acheson graphite are luted in at E by a

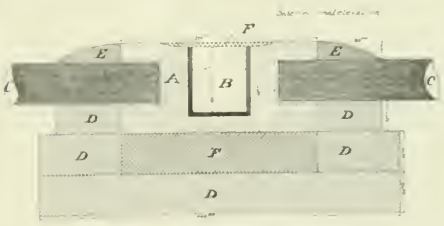


FIG. 7.—VERTICAL SECTION.

cement composed of equal parts of fire-clay and siloxicon. The fire-clay brick work D is laid in the same cement, all joints being closed tight.

The resistor A is of crushed coke, and no particular care is used in grading it to a certain size. It will probably average 20 mesh, and the finer sizes are to be avoided as they will cause blowing which scatters the coke by the gas pressure formed.

The crucible B, also of graphite, may vary in size, but that shown in the figure has been found to give satisfaction, although a smaller size turned from the regular 2-inch electrodes answers in many cases.

A great difference has been found in using coke for the resistor which has been previously used for resistor purposes as compared to fresh coke as it comes from the gas retorts. If new coke is used it will take a much higher voltage to start the run, and great care must be taken not to get too great a gas evolution during the time that the volatile matter in the coke is being eliminated. Otherwise the same blowing will

take place, causing the general upsetting of the furnace. With old coke it is easy to start the run in, and there is little chance of blowing. The crucible can therefore be heated to a high temperature in a very short time.

Indeed, with a furnace of the dimensions shown, Prof. Tucker has been able to reduce any oxide which can be reduced in the arc, with the great advantage that the temperature is more easily regulated and a more uniform product obtained.

The usual difficulty of increasing the carbon contents, due to the retaining vessel being of that material, is naturally present in this furnace as in all others using carbon. It is, however, possible to substitute a magnesia crucible for the graphite if the required temperature is not above the melting point of magnesia.

Alternating current is most suitable for operating this type of furnace, as perfect control may be obtained by variation in the voltage by means of the field of the alternator or by means of an auto-transformer. With direct current the rheostat would have to take very heavy currents and there would be great loss of power.

With a furnace of this size the crucible will not be heated evenly, particularly at the start, for the reason that there is a concentration of the current density at the points directly opposite to the ends of the electrodes. To overcome this objection charcoal may be packed around these points of the crucible. This is easily done by placing a curved piece of sheet iron against the crucible at these points when filling in the coke, so as to leave an open space between the crucible wall and the sheet iron. This open space is then filled with charcoal and the sheet iron is withdrawn. The charcoal is practically a non conductor, and causes the current to pass to the sides of the crucible.

A cover turned from graphite is quite suitable to retain the charge in the crucible. For the treatment of a large quantity of material a shaft may be set on the top of the crucible

Granular Carbon Resistance Furnace

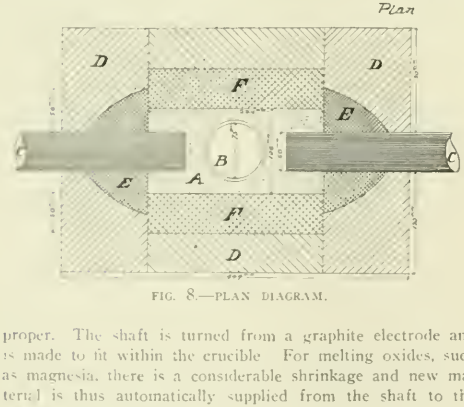


FIG. 8.—PLAN DIAGRAM.

proper. The shaft is turned from a graphite electrode and is made to fit within the crucible. For melting oxides, such as magnesia, there is a considerable shrinkage and new material is thus automatically supplied from the shaft to the heated portion of the crucible. This arrangement also acts as a condenser containing any volatilized portion. In the case of magnesia this is important, as at ordinary pressures there is considerable loss of material due to this cause.

On account of the fumes evolved from the ash and the coke as well as the heated brick walls it is exceedingly difficult to determine the temperature by the optical pyrometer in this furnace. Prof. Tucker made, however, several attempts with a graphite tube, the end of which fitted into the crucible and through which the pyrometer readings were made from the side of the furnace.

In the paper some numerical results are given, obtained in the production of titanium carbide, chromium, etc., in this furnace.

Some experiments in running the furnace with new and old coke showed that the time required to reach the same temperature is very much longer for new coke than for old.

In the discussion which followed Mr. Hering asked whether an allowance had been made for the expansion of the tube of Prof. Tucker's tube furnace when it becomes hot. Dr. Tucker said he had experienced no difficulty but if necessary one of the clamps could be so adjusted so as to allow for any expansion. Flexible connections may be necessary in commercial furnaces.

Electrolytic Corrosion of Brasses.

Dr. A. T. Lincoln then presented a paper embodying the results of his very extended experimental investigation for which the American Electrochemical Society had granted him the prize of $100 for original research. The investigation must have involved an enormous amount of experimental work and it is not possible to do justice to the paper without reproducing all the diagrams, photographs, etc. The following abstract is therefore only an outline of the contents of the paper. After giving the Roberts-Austen diagram of the different phases in which brasses occur the author described the electrolytic corrosion of different brasses in different salt solutions.

For instance, with a sodium chloride solution, as the copper content decreases in the copper-zinc alloy the amount of corrosion decreases until we reach about 50 per cent copper composition. Then the corrosion remains constant and is practically pure zinc corrosion. These results were given in diagrams and analogous measurements were made for sodium nitrate, sodium sulphate, ammonium nitrate, potassium nitrate, etc. In sodium chloride the chemical corrosion is practically parallel to electrolytic corrosion.

The author then dealt with the very characteristic appearance of samples under the microscope after corrosion, pictures of characteristic crystals being given. Finally, complex brasses were also tested by the introduction of small quantities of tin into the copper-zinc alloy.

In the discussion, Prof. Bancroft said that this work had been brought out very clearly, that there is a great multiplicity of phenomena in the corrosion of alloys. We can predict nothing with safety. If it is true that electrolytic corrosion is parallel to chemical corrosion then it is wrong to believe that Muntz's metal is the only one which corrodes in salt water without change of composition; there must be a much wider range. Dr. Richards suggested tests directly using sea water instead of the different constituent salt solutions in it.

The Electrolytic Deposition of Nickel-Zinc Alloys.

A paper on this subject by Dr. E. P. Schoch and A. Hirsch was then presented by Dr. Schoch. In former determinations of the voltages there is a difference of 0.5 or 0.6 volt between the deposition voltages of nickel and zinc. In view of this it is remarkable that no good method for the electrolytic separation of nickel from zinc has been developed. Dr. Schoch then referred to difficulties which they had experienced in plating nickel-zinc alloys from nickel-zinc solutions, and in which they could not get deposits as rich in nickel as they desired. It was therefore decided to first determine again carefully the tension of zinc and nickel, and the chief result of the authors' determination is that they found a higher value for nickel than had been obtained heretofore.

Electric Zinc Furnace.

A paper by Mr. Edward R. Taylor, of Pen Yan, N. Y., was then presented, in which he described a modification of his bisulphide of carbon furnace, especially suitable for the distillation of zinc, lead, etc. The furnace has already been described and illustrated on page 103 of our March issue, to which the reader may be referred. Mr. Taylor remarked that the use of broken carbon as electrode, as introduced by him in the bisulphide of carbon furnace, has proven exceedingly successful in several years' experience on a large scale. It is

very cheap and suitable for continuous operation. While this zinc furnace has already been tried on an experimental scale he has not yet come down to large-scale operation, and a furnace like this can show its full possibilities only on a large commercial scale. This interesting paper was discussed by Messrs. Tucker, Sperry, Emrich and Hering.

ADDRESS OF THE PROVOST OF THE UNIVERSITY OF PENNSYLVANIA.

After Mr. Taylor's paper the regular course of the proceedings was interrupted to give the distinguished provost of the University of Pennsylvania, Mr. HARRISON, an opportunity to address the meeting. He regretted that he had not been able to speak at the beginning of the meeting, but was very glad of the great success of the convention. He assured the American Electrochemical Society that the University of Pennsylvania was always glad to be the host of the Society. He also referred to his own family connections with chemical engineering, the chemical laboratory of the University of Pennsylvania bearing the name of one of the first chemical manufacturers, John Harrison.

After Mr. Harrison had left, Prof. E. F. Smith said he was very glad that the Society had an opportunity to see Provost Harrison, who has done so much for chemistry and for the University of Pennsylvania. To him the University owes its Laboratory of Chemistry, and also a donation of $500,000 for scholarships. Dr. Smith sketched briefly what Mr. Harrison has done in the twelve years of his administration.

This little incident with the speeches of Messrs. Harrison and Smith was highly enjoyed.

CARBON IN ELECTROMETALLURGY.

A paper by Mr. F. A. J. FITZGERALD, of Niagara Falls, and Dr. J. FORSSELL, of Cleveland, was then presented in abstract by Mr. FitzGerald. The authors have made very elaborate tests on the use of amorphous carbon and graphite for electrometallurgical purposes. In view of the extended series of measurements which were made by the authors, only an outline was given in the present paper of the arrangement of the experiments, while all the results were reserved for further publications. The resistivity of various graphite electrodes and amorphous carbon electrodes and the resistance of different types of joints were investigated, etc.

One of the peculiar observations made during the tests was that identical carbon rods in series which should have given the same voltage drop behaved differently inside and outside the furnace. It was found that the carbon inside the furnace always showed a much greater voltage drop than outside, even before the carbon was ever hot. In the discussion several attempts were made to explain this curious phenomenon, but no conclusive results were obtained. We will have an opportunity to return to the very interesting and valuable measurements of Messrs. FitzGerald and Forssell in a later issue.

OXIDATION HEAT OF SILICON

A paper by DR. HENRY NOEL POTTER gave details of a bomb calorimeter for measuring the heat of combustion of substances giving solid oxidation products. The author used a bomb calorimeter of the Berthelot type but of a modified construction to suit the special purpose. First, a heavily gold-plated lining was used and later on the lining was modified so that there were two concentric bombs. For details of the construction the reader must be referred to the full paper, which will be published in the *Transactions*.

The chief result obtained with this bomb was the oxidation heat of silicon free from carborundum, which was found to be 7594.8 gram calories per gram of silicon, or $28.4 \times 7594.8 = 215{,}692$ gram calories per gram equivalent.

In the discussion, in which Messrs. Reed and Richards participated, the latter pointed out the great importance of this numerical value for metallurgical calculations

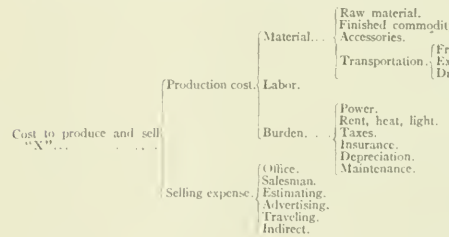
ELECTROCHEMICAL PROCESSES AS STATION LOAD EQUALIZERS

A paper by Mr. JOHN MEYER, of the Philadelphia Electric Company, was in form of a reply to a paper by Mr. Elmer A. Sperry, presented at a former meeting on the same subject.

Mr. Meyer's paper was a discussion of the commercial aspect of this subject from the central station viewpoint, with the hope that electrochemists and electrometallurgists will give this matter further consideration.

The final location of a plant for electrolytic or metallurgical processes, not unlike manufacturing will result from the knowledge of all costs involved in the process, and not alone the cost of current. To illustrate: A large Philadelphia concern desired a location for its manufacturing plant. Several water-power sites were examined, including Niagara Falls. It was decided, after a careful analysis of all costs (and in the face of cheap water power) to erect the plant in Philadelphia. The actual power cost as determined by several years actual operation indicate that if the lighting company had had the existing rates in force at the time the steam plant was decided upon, the plant installation would never have been made. It would appear, therefore, that the cost of power is not the deciding factor.

Assume the intention to erect a plant for the production of a commodity which we will call "X." What factors should be considered? The following schedule shows graphically the several items which should be considered:



In Mr. Mayer's analysis neither the selling price or the profit was considered, upon the assumption that the selling price is fixed by the law of supply and demand, and the profit will presumably be the difference between the cost to produce and sell and the selling price. Mr. Meyer quoted from a recent paper of Mr. C. J. Russell, of the Philadelphia Electric Company:

"While the tendency seems to be to locate such industries where water power is available, there are other factors which may help the central station to secure consideration in the matter of current supply. The question of facility and low cost of transportation of raw materials and the location of principal market centers for finished product are important to any industry.

"There are some electrochemical industries located now in out-of-the-way places which could obtain better results near some of our great shipping centers, for the reason that the cost of transportation of raw and finished product plus the loss of certain by-products which cannot now be utilized, more than offsets the advantages gained by the price of electricity at the present location

"While water power may seem reasonable these items of expense may make central station service in some other and more favored locality the cheaper in the end."

An investigation as outlined above may prove it more desirable to locate an electrolytic plant in Philadelphia in preference to Niagara Falls or elsewhere where such low rates have been quoted. Assuming such to be the case, the problem is then reduced to a comparison between the power costs of central station supply versus isolated plant.

The items enumerated below are those that can generally

be considered as making up the total cost of operating an isolated plant:

Salary of engineers.
Salary of firemen.
Salary of electricians.
Fuel.
Removal of ashes.
Water
Repairs to boilers, engines and dynamos.
Tool account.
Miscellaneous expense
Supplies, oil and waste.
General expense.
Depreciation.
Interest in investment.
Insurance—fire and boiler.
Rental value of space occupied by plant.
Liability insurance.
Taxes.

Having obtained the total operating cost we invariably but erroneously divide this cost by the capacity of boiler, engine or generator and obtain a cost per horsepower or per kilowatt per year. Either result divided by 8,760 hours produces a rate per horsepower-hour or per kilowatt-hour. Undoubtedly the cost per kilowatt-hour is the only correct basis for comparison. However, the foregoing method of arriving at the cost per kilowatt-hour is incorrect, inasmuch as it does not consider the relation between the theoretical and the actual power generated.

The theoretical kilowatt-hour per annum may be found by multiplying 8,760 hours by the rated kilowatt capacity of the generator or the maximum amperes × volts when all the cells or other apparatus are in service.

The actual kilowatt hours per annum will be a modification of the theoretical kilowatt hours depending upon the time lost in repairs to or overhauling of furnaces, cells, etc. It may be obtained fairly accurately by multiplying the number of pounds of "X" produced in any year by the watt-hours required to produce 1 pound. Dividing the total power cost by the actual kilowatt hours thus obtained will probably produce a rate comparable if not higher than the rate named by the central station.

The fixed charges on the investment necessary to carry the electrolytic load over the central station peak must be considered in making rates. With this peak factor eliminated lower rates could be named.

In conclusion, Mr. Meyer said that central station managers in general are anxious to connect such desirable business and are open to any suggestions that may solve the problem. A great deal of good would result if a committee were appointed, consisting of the interested parties, with instructions to investigate and report at a next meeting.

The paper was discussed by Messrs. Sperry and Taylor.

Mr. Sperry referred to statistical data showing that the average load factor of power stations is about 25 per cent, so that in the average 75 per cent of all the machinery is idle. It would be highly beneficial if all the machinery could be utilized at full load all the time. He also expects much from the development of power from blast furnace gases. Mr. E. R. Taylor expressed the opinion that while electrochemical industries have to take power at present where they can get it, it will be of vital importance for them later on to develop their own power.

Power Costs.

The next paper on the program was on power costs, the author being Prof. Charles E. Lucke, of Columbia University. The paper had originally been presented before the New York Section of the American Electrochemical Society, and printed copies were obtainable at the meeting, together with the discussion in New York by Messrs. F. G. Clark, J. Bijur, L. H. Baekeland, C. O. Mailloux, E. J. Berg, P. Torchio, P. R. Moses, Emmet and M. Namba. The gist of the paper is contained in the following conslusions:

Comparison of power costs on assumed conditions; stations consisting of six units, two in reserve and four working on 24 hours rated load, with the exception of the water power. First cost and fixed charges are based on the capacity of 150 per cent of the output.

	Water Power.	Oil Engines.	Gas Engine and Prod.	Steam Engines.
First cost per kw. rating	$75 00—200 00	160 kw. units. $217 00	600 kw. $270 00	5000 kw. $110.00—150 00
Fixed charges, rate per cent.	10 per cent.	10 per cent.	10 per cent.	10 per cent.
Fixed charges, per kw. year	7 50— 20 00	21 70	27 00	16 50— 22 50
Operating and mfg. costs per kw. year	1 00— 5 00	56 94	38 54	52.56
Total power costs per kw. year	8 50— 25 00	78 64	65 54	69 00— 75.00

"From these figures it appears that we have not yet reached the limit of cost of development of water powers which may be advisable. It apparently would pay to spend even more money than $200, the present maximum per kilowatt for water power development, if there are no other considerations entering. Among the chief considerations of this kind may be set down that of transportation of products from the works and raw material to the works, but this must be considered against the question of transmission of current from the water fall to a convenient point of transportation.

"It is interesting to note how close is the cost competition of the three fuel systems for the conditions assumed for each.

"Excluding the water-power plants, the first cost of the steam plants will be least, oil second and gas engine greatest, with the fixed charges in proportion. As oil fuel is very much more expensive than coal, when referred to the heat contests, and the thermal efficiency of the oil engine not as much greater in general, it follows that the fuel element in power costs will be greater than for the steam or gas plants, except when small and load intermittent. This fuel element will always be less for gas plants than for steam when the same coal is available for both. This fact, compared with the increased fixed charges for gas plants, makes it likely that gas power will be cheaper than steam when the load factor is high, and the difference will be greater the greater the cost of coal. Smaller units in every case will have the effect of increasing labor cost per kilowatt hour, but not in proportion to size reduction. Oil, waste, miscellaneous supplies and maintenance and repairs will depend on the complication of apparatus, its service and the quality of labor employed, but its value is problematic and cannot be predicted, except by experience with similar apparatus, which gives figures on which to base estimates."

In discussing briefly the paper at the Philadelphia meeting Mr. E. A. Sperry thought that Lucke's values were generally too high or too conservative, while on the other hand, Hutton's values (Electrochemical and Metallurgical Industry, Vol. V., page 24) appeared to him too low. Mr. Sperry thought that development would lead to production of power in central station at the cost of $33 to $24 per horsepower-year, or $44 to $32 per kilowatt-year.

Helion Lamp.

Prof. H. J. Parker presented a paper on the helion lamp, invented by Mr. W. G. Clark and developed by him in connection with Prof. Parker. It was pointed out that the higher the temperature of the filament the colder the light. Not the melting point but the point of evaporization is of importance. Pure silicon has a melting point of 1,400° C.; in view of this fact it seemed almost helpless to try silicon for incandescent lamps, since in order to get a lamp of an efficiency of 1 c. p. per watt one needs a temperature of at least 1,200° C.

On the other hand, Prof. Parker claimed that silicon has the

least vapor tension of anything known, and this makes it very suitable for filaments. The chief result of the work in the development of the helion lamp was that they were able to change the ordinary silicon into "metallized silicon," which does not melt up to 2,100° C. He thinks that the "helion" has the same relation to ordinary silicon as the metallized graphite of the "metallized filament" lamp of the General Electric Company has to ordinary carbon.

Since a carbon core is used for the filament and silicon is coated on it, the hypothesis had been offered that the filament was really carborundum or a silicon carbide. But Prof. Parker doubted vigorously that it was carborundum, and did not think it was a silicon carbide although he could not absolutely deny the latter possibility. He preferred to believe in the hypothesis of a "metallized silicon." The lamp has an efficiency of 1 c. p. per watt.

In the discussion Mr. Clark called attention to the temperature-light curve. Take the characteristic of the carbon filament, then coat it with silicon and take again the characteristic. At any point the light is increased for a certain temperature. Mr. Gaster, a delegate of the Faraday Society, and Prof. Tucker also took part in the discussion, and in his reply Prof. Parker said that at the end of 1,230 hours the decrease in candle power of some lamps tested was only 3 per cent, but other results were obtained with other lamps and no conclusive results were yet available.

SURFACE PROPERTIES OF ALUMINIUM AND ZINC.

Mr. W. J. HAMMER, of New York City, lectured briefly on some experiments which he had made concerning peculiar surface properties of aluminium and zinc. It is well known that the surfaces of these metals are generally coated in the ordinary atmosphere with a film which is assumed to be an oxide film. The presence of this film has very distinct effects. Mr. Hammer believes that microphotographs would give good information on the subject. On the other hand, he has also made purely mechanical tests, for instance, with drops rolling on surfaces on differently inclined grades, etc.

PAPERS READ BY TITLE.

The following papers were read by title, and since no printed advance copies were available it is impossible to abstract them here. The papers will be printed in full in the *Transactions:*

"The Electrometallurgy of Zinc and Its Relation to Present Practice," by WOOLSEY MCA. JOHNSON.

"Moissan's Life and Work," by Dr. G. F. KUNZ.

"Carborundum, Artificial Graphite and Artificial Diamonds," by Dr. G. F. KUNZ.

"On the Density of Certain Fused Salts and Their Mixtures," by Dr. H. M. GOODWIN and R. D. MAILEY.

"The Present Status of the Thermodynamic Scale," by E. BUCKINGHAM.

EXHIBITION.

During the meetings an exhibition of various instruments and apparatus interesting for electrochemical and chemical engineers had been arranged in one of the rooms of the John Harrison Laboratory. Demonstrations of these instruments were made after the close of the meeting on Saturday.

The LEEDS & NORTHRUP CO., of Philadelphia, exhibited various measuring instruments, among them their type K potentiometer, regulating rheostats and a Kohlrausch slide-wire bridges and an amme er based on the "pinch effect."

The WILLSON-MAEULEN CO., of New York City, exhibited several tubes of electroquartz, suitable as pyrometer tubes and for other purposes.

The DECKER ELECTRICAL MANUFACTURING CO. of Philadelphia, exhibited several Decker primary cells for automobile use as well as special porous diaphragms of their manufacture for other purposes (see our Vol. IV., p. 441; Vol. V., pp. 58, 104, 144 and 195).

Messrs. EIMER & AMEND, of New York City, exhibited several electric furnaces, a muffle furnace, electric stirrers, hydrometers and other instruments.

During the Saturday session Mr. HENRY G. MORRIS described briefly the Kestner evaporator which is designed by Mr. Paul Kestner, of Lille, France, and is now being introduced in this country.

Film evaporation has been known and recognized for many years as the most effective and most desirable method of concentrating liquors. Various attempts have been made to secure a uniform distribution of the liquor over the heating surface, which has resulted in great complication of circulating pumps, float valves, deflectors and regulators of various forms. In some of these attempts have been made to make the film of liquid adhere to the outside surface of heated horizontal tubes. In these forms of evaporators great care must be taken that the liquid is distributed in an even film over the tubes, and furthermore, the liquid is always tending to fall from the tube before the maximum concentration takes place. The float valves and circulating pumps give more or less trouble, and the distribution boxes require careful adjustment.

The feature of the Kestner climbing film evaporator is that the distribution of the film over the heating surface is rendered automatical and does not require pumps, float valves and distribution boxes. The film is spread over the heating surface by the disengagement of the steam instead of the reverse as usually takes place.

The tubes in a Kestner evaporator are ordinarily vertical and are about 23 feet long. The liquid is fed at the bottom and the supply is so limited that the tubes are practically empty. At the start the liquid begins to boil in the tubes and very shortly such a violent ebullition occurs that the vapor, occupying many times the volume of the liquid, rushes through the tube at such a velocity that it carries with it against the hot walls of the tube a thin film of liquid, which, together with the vapor, is discharged against suitably designed vanes of a centrifugal separator. By means of this the concentrated liquid is whirled against the walls of the vapor belt, and the vapor, thoroughly separated from the liquid, passes off to the next pan or to the condenser.

VISITS, EXCURSIONS AND SOCIAL FUNCTIONS.

After the close of the meeting on Wednesday the members were the guests of the University at luncheon in Houston Hall, on the University grounds.

After luncheon an inspection was made of the chemical and engineering laboratories of the University of Pennsylvania.

This was followed by a visit to the large experimental plant of the United Water Improvement Company, where the electrical production of ozone for water purification was shown. Two different types of ozonizers are used side by side, one employing a glass dielectric, the other no dielectric whatever. The latter system is that of Vosmaer. The sterilization of Schuylkill water (after previous filtration) by means of a stream of ozone gas bubbling up through a long tube in which the water runs down was shown outside of the building. The claims were made that the effect of ozone treatment on Schuylkill water, which contains besides various organic substances 3,000,000 bacteria per cubic centimeter, was to oxidize completely the organic matter and to reduce the number of bacteria to less than 5 per cubic centimeter, the power consumption being 1 kw-hour per 1,000 gallons of water.

A visit was then paid to the large plant of the John F. Lewis & Bros. Co., where the manufacture of white lead and red lead was shown. For the evening of Thursday a theater party had been arranged to Keith's Theater, Chestnut Street.

On Friday afternoon an excursion on the Delaware was enjoyed. The city of Philadelphia, through the kindness of the Mayor and the Director of Public Safety, had tendered to the members of the Society the use of the city fireboat *Ashbridge*. The boat took the party first to Tacony, where the enormous

aw works of Messrs. Henry Disston, Sons, Inc., were visited. This company was the first in the United States to introduce the electric induction furnace into practice for the manufacture of high-grade steel of crucible-steel quality. The success has been so great that they are now considering the installation of a much larger electric furnace plant. The original furnace (a photograph of which, taken when at the Disston works, is reproduced in Fig. 9) has been removed from the works to a building near Lardner's Point Pumping Station for a series of very careful tests. Here the furnace was shown in operation to the members.

This furnace was manufactured by the Induction Furnace Co. of America under the patents of Mr. Edward A. Colby. It is rated at 131-kilovolt amperes. The voltage of the single-phase primary current is 240 volts, the maximum current 540 amps, and the frequency is 60. The primary consists of 28 turns of copper tube, 3/8 inch inside and 5/8 inch outside diameter, and is cooled by internal water circulation. The annular crucible which, with its contents, forms the secondary of the transformer furnace, is a one-piece crucible, 14 7/8 inches inside and 24 1/4 inches outside diameter, 8 inches in height. The trough is 6 3/8 inches deep, 2 7/10 inches wide at top and 2 inches at the bottom, with a working capacity of 190 pounds of steel. The current in this crucible is, at a maximum, 15,148 amps. at 8.57 volts.

Ingots of 90 pounds can be poured every hour, leaving 100 pounds in the crucible. Fresh materials are then added at once. The fusion is complete in half an hour. The refining and killing takes the other half-hour. The steel lays very still in the mold. The ingots are very dense and homogeneous.

The present-size crucible requires 40 kw. at the maximum. The current regulation is practically controlled by the amount of metal in the crucible. External control is only necessary to control the temperatures during refining and boiling out gases.

The current used per 100 pounds of metal poured varies from 27.5 to 37.5 kw-hours, according to the nature of the charge and the percentage of carbon desired in the finished product. It was stated that the pinch effect has never been observed in this furnace. The calculated resistivity of steel is of little use in calculating the amount of current required in the primary, as the section of the current is constantly altering, due to liberated gases.

The members then visited the Lardner's Point station, where Mr. Charles J. Russell, of the Philadelphia Electric Co., had prepared a very interesting exhibition and demonstration of various models of electric furnaces. This exhibition is shown in Fig. 10.

The furnace at the left of the picture is a kryptol furnace, kryptol being the well-known granular carbon resistance material. This furnace is very convenient for melting 2 or 3 pounds per crucible of metals or alloys. Plates of Acheson graphite are placed at each end of a chamber built up of refractory materials, and the crucibles are plunged into kryptol, which is packed around them. Different temperatures are obtained in each crucible by taking off the cover and reducing the depth of kryptol around the one to be heated to the higher point. The furnace consumes about 7 kw. and is operated at 110 volts. By inserting resistance in the circuit the temperature may be readily controlled. Ordinary operations require current for 20 minutes when starting with cold materials.

The next furnace, No. 2, was an arc furnace with two electrodes, something on the order of the Héroult furnace which has been used for reduction of magnetite by charcoal in the well-known tests at Sault Ste Marie. The small experimental furnace holds 100 pounds. The arcs are produced between the electrodes and the slag on top of the metal. From 300 to 500 amps. at from 35 to 40 volts are used at each electrode, making the total power consumption in the furnace from 21 to 40 kw. This furnace has been used experimentally in reducing iron ores. Fine grade of steel has also been produced by starting with pure concentrates and subsequent refining in an induction furnace.

The third furnace shown was a single-electrode arc furnace of the type used by Siemens, Willson, Héroult and others. In this case the crucible and its contents are connected to one pole

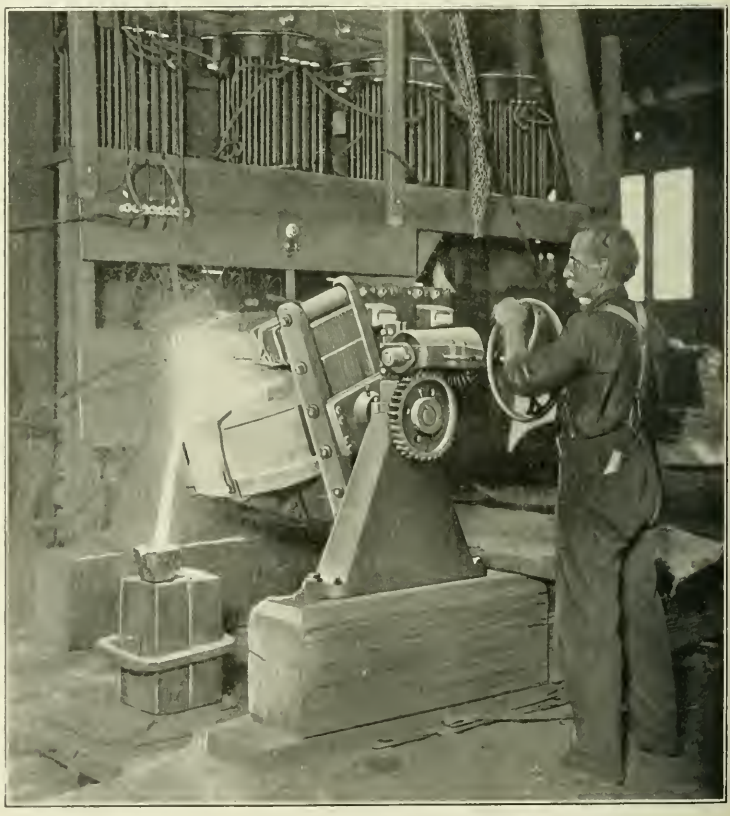


FIG. 9.—COLBY ELECTRIC STEEL FURNACE.

of the circuit and the moveable electrode to the other. The current used in this model is from 300 to 500 amps. at 35 to 50 volts, which represents a total capacity of from 10.5 to 25 kw. This model has been used principally in the production of carbides of various metals. The furnace was shown in the

PHOTOGRAPH TAKEN ON EXCURSION BOAT. PRESIDENT HERING AND PRESIDENT-ELECT BURGESS IN FRONT ROW.

course of making titanium carbide. The character of the arc was very noticeable. The furnace may, of course, be used both with alternating current and with direct current.

The fourth furnace is a barium-chloride furnace of the type understand that same samples of high-speed steel were recently hardened in Philadelphia in this furnace. There was absolutely no effect on the surface of the steel and the pieces come out as pretty a finished product as can be imagined.

The electrodes of this furnace are of wrought iron. The bath consists of fused barium chloride for temperatures above 1,000° C. For lower temperatures a mixture of chlorides of barium and calcium is used. This is the first furnace of commercial size shown in this country. The size of the bath is $7^7/_8 \times 7^7/_8 \times 10^5/_8$ inches. It takes about half an hour to heat the furnace up thoroughly, and the power consumption ranges from 8.5 to 12 kw. A wide range of temperature is possible by adjusting the voltage. Since the current density in the molten bath is practically uniform the temperature within the bath, except in the thin layer in the upper surface, is found to be very uniform.

In coal or gas-heating of articles made of high-speed steel for tempering, sharp corners are broken down and sizes are altered by scaling due to oxidation. On the other hand, articles treated in this electrically-fused chloride bath come out perfect. Articles requiring to be heated to a high temperature, such as high-speed tool steels, can be immersed in the bath without oxidation and other chemical action and can be quickly brought up to the required temperature. The field for the application of this furnace seems very large and important.

Upon the bench on the right of Fig. 10 was exhibited a device for heating a combustion tube by means of kryptol. This consists of an inner and outer containing tube with a kryptol powder packed between them. Contact is made by terminal blocks of Acheson graphite. A wide range of temperatures may be obtained by the use of supplementary resistance control. On the same bench two small arc furnaces of the Moissan type were shown in operation. A small model of an induction furnace was of interest as showing the principle of the construction of this type of apparatus.

The furnaces shown in this exhibition were installed expressly for the occasion, and were with the exception of the barium-chloride furnace, models of types used in experimental work by Mr. C. J. RUSSELL, who should be sincerely congratulated for his success in arranging this very interesting exhibition as well as for his good and persistent work in bringing central station men and electrochemists together.

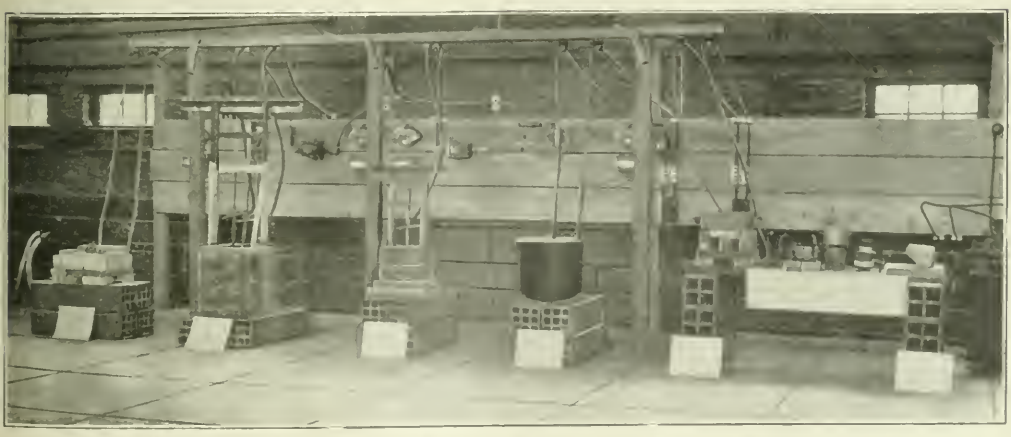


FIG. 10.—EXHIBITION OF ELECTRIC FURNACES AT LARDNER'S POINT STATION

controlled jointly by the Allgemeine Elektricitäts-Gesellschaft, of Berlin, and the General Electric Co. in this country. It is specially adapted for use in hardening and annealing, and has met with considerable success in this field and in European countries. (See also pp. 367 and 514 of our Vol. IV.) We

The party was then taken back to the boat for a ride down the Delaware, passing the Philadelphia and Camden water fronts with all their large industries, including Cramp's ship yards, the New York Shipbuilding plant, the By Product Coke Ovens, the sugar refineries, the League Island Navy Yard, etc

After arrival at Gloucester a visit was paid to the works of the Welsbach Light Co. All the different steps in making and finishing an incandescent gas mantle could be seen in the different departments, and the way it is being done, to have such very delicate things produced on a large scale almost exclusively by young girls, with the aid of special machinery, was greatly enjoyed by the visitors.

The boat then took the party to Washington Park, where the landing of the shad nets was seen (though with some difficulty on account of the darkness) and a planked shad dinner was enjoyed afterwards. After-dinner speeches were made by President Carl Hering, President-Elect C. F. Burgess, Dr. C. P. Steinmetz, Prof. Wilder D. Bancroft, Prof. J. W. Richards, Dr Charles Baskerville and Mr. W. J. Hammer. Mr. H. B. Coho was as ever an excellent and jovial toast master.

On Saturday, after the demonstration of exhibits, the members were again the guests of the University at luncheon at Houston Hall. A visit was then paid to the United States Mint, at Seventeenth and Spring Garden Streets, where the electrolytic plants for the refining of gold and silver were visited under the direction of Dr. D. K. Tuttle and Mr. Leonard Morgan. The Wohlwill process in use there has been described in detail in our Vol. I., p. 157, and our Vol. II., pp. 221 and 261. The Tuttle process of refining silver and the whole process of refining both gold and silver at the Mint was described in our Vol. IV., p. 306.

The meeting as a whole was a full success in every respect and was exceedingly enjoyed by all who attended it. The number of members who registered were 123, besides eight guests, but the attendance at the meetings was at times larger rising to a "peak load" of more than 180 during Dr. Steinmetz's lecture on Friday.

For the first time in the history of the Society quite a number of ladies participated in the excursions and contributed much to their success and enjoyment.

The next meeting of the Society will be held in Autumn in New York City.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

Metallurgical Research at the National Physical Laboratory During 1906 and 1907.

The report of the executive committee of the National Physical Laboratory for last year is, as usual, a document of much scientific interest, not least upon its metallurgical side.

The chief work of the year of this section has been the research into the properties of the alloys of aluminium and copper, which is embodied in the eighth report of the alloy research committee of the Institution of Mechanical Engineers. In addition the alloys research committee have asked for certain further tests on some of the copper-aluminium alloys, particularly as to their behavior in tension at high temperatures (*i. e.*, up to 500° C.) and their behavior when exposed in the sea for long periods of time. Preliminary arrangements for carrying out this work have been made; for tensile testing at high temperatures an electrically heated furnace has been designed and its construction is in hand. The "furnace" is tubular and the specimen is heated by radiation only. By means of this appliance it is hoped that tensile tests on specimens 2 inches between gauge marks may be carried out at any desired temperature up to at least 500° C.

For the sea-water corrosion tests arrangements are being made for specimens to be exposed in the sea at Portsmouth, where they will be accessible for periodical inspection.

Investigation of a further series of alloys, probably of aluminium, will be undertaken and carried out on lines similar to those adopted in the case of the copper aluminium alloys, but the alloys research committee have not yet definitely decided what alloys are to be studied.

Cooling Curve Methods.—An investigation of the differential method of taking cooling curves has been begun, and indications of interesting results have already been obtained; this work will be continued, and it is hoped that a paper embodying the results will be published early in the year.

Eutectic Alloys Research.—It is proposed to investigate the physical structure and mechanical and thermal behavior of eutectic alloys. At the present moment there is a marked gap in our knowledge of these bodies. The physical structure of pure metals and the changes which this structure undergoes when the metal is mechanically deformed, as also the process of crystallization and crystal growth both at and below the freezing point, have been very fully studied, principally by the aid of the microscope, by a number of investigators, and the conclusions reached command wide acceptance. The eutectic and "eutectoid" bodies are, however, not nearly so well understood and have been very little studied from this point of view, probably because their usually minute structure renders the study more difficult than in the case of pure metals. It is thus at the present moment an open question whether the structure of "eutectic and eutectoid" bodies is, like that of pure cast metals, truly crystalline or not—the phrase that at a certain temperature an "eutectic crystallizes" being based chiefly on the analogy of homogeneous bodies such as pure metals of solid solutions. Even if the generally crystalline character of these bodies be admitted or assumed, the detailed nature of the crystalline arrangement remains to be determined so as to decide whether there is any uniform crystalline orientation throughout a "grain," consisting of many lamellæ of both constituents of the eutectic, or whether each lamella is an individual crystal. Spherulitic structures may also occur. It is further to be decided whether eutectic bodies are alike in this respect or whether different modes of solidification prevail in different groups of elements. In another aspect of the same question the thermal behavior of the eutectic alloys is to be studied; it is well known that by suitable thermal treatment the two constituents may be caused to separate or segregate more and more completely, and it is important to determine the course of the process of fusion in such a case; *i. e.*, to determine whether the melting point is raised by such segregation and what intermediate stages—if any—occur prior to actual fusion; the study of transition products in the formation and fusion (or absorption) of eutectic or eutectoid bodies is of special interest in connection with the less known structural constituents of steel ("sorbite" and "troostite"). It is hoped, however, that careful study of these phenomena upon the following lines may throw some light on the causes of the relatively very low melting points of the eutectic alloys.

(1) Preparation of as great a variety of "eutectic" and "eutectoid" bodies as possible in a state of approaching purity —including the exact determination of their composition and melting and freezing points. Of the series so prepared, characteristic members are to be selected for further study.

(2) Study of the micro-structure of the eutectic bodies and the effects of slow and rapid cooling and other heat treatment on the structure.

(3) Study of the microscopic effects of strain upon these bodies as differently treated; microscopic study of the mechanism of plastic deformation and of the path of fractures produced in various ways—the results being correlated, where possible, with the mechanical properties of the alloys in various conditions. (2) and (3) above make a very severe demand upon the capacity of the microscope, since it is probable that some of the features to be observed lie at or even beyond the limits of ordinary microscopic resolving power. The limits of microscopic resolution have, however, recently been pushed considerably further by the introduction of

microscopic appliances for the utilization of ultra-voilet light of short wave length (0.275), yielding *effective* magnifications up to 3,000 diameters, and it is proposed to apply this apparatus to the study of the minute features referred to above.

(4) The processes of solidification and fusion to be studied thermally and microscopically, by means of heating and cooling curves and by the examination of specimens suddenly cooled at intermediate stages of both processes.

(5) The formation of eutectic bodies without the intervention of fusion; *i. e.*, by diffusion of solid metals with and without the aid of pressure, and by electric deposition and study of the structure and properties of the bodies so formed.

(6) Formation and study of ternary and quaternary eutectic alloys.

The engineering department have also a schedule of interesting work to be undertaken in 1907.

(1) *The Resistance of Materials to Impact.*—As the chief object of this research is to determine the simplest and best method by which a measure of the capacity of a given material to resist shocks can be obtained, it is proposed to carry out a larger number of tests on about one dozen samples of steel and iron of the kind in commercial use at the present time. These tests will be made on each of the three impact testing machines which have been already constructed in the workshop, and on the 1zod impact tester lent by Messrs. Avery. The experiments with these four machines will, it is hoped, reveal the relative merits of the "single blow" method and the "repeated blow" method. Concurrently with these tests statical tests are being made on similar specimens to determine the total work done in fracture, so as to be able to compare the values so obtained with the energy of the blow to cause fracture in the impact test. In the case of the specimens tested on the machine for alternating direct stresses due to impact, it is proposed to subject them to microscopical examination during the progress of the tests and to obtain photographs of the gradual development of the slip lines into cracks.

It is then proposed, by means of the methods of testing developed in the preceding research, to undertake the investigation of the properties of certain materials which have proved weak under shock without apparent cause, and for this purpose to invite engineers in practice to send samples of such materials to the laboratory. Capt. Sankey and Mr. Stromeyer have already kindly offered to help the laboratory in this matter. It is further proposed at the same time to investigate the effect of various kinds of heat treatment on resistance to shock in the case of iron and steel.

(2) *The Elastic Limits of Material Under Alternating Stress.*—For the paper on alternating stress which has been published certain experiments were made on the elastic limits of specimens which had been subjected to a considerable number of reversals of direct stress, which showed an agreement of the range between the elastic limits as determined by a sensitive extensometer and the range of stress for which fracture will just not occur after indefinite repetitions of the stresses.

It is proposed to add to these preliminary results and to further examine specimens of iron and steel with the object of arriving at a definite conclusion. By subjecting these materials to a number of reversals of stress of a range less than the limiting range and examining by means of an extensometer, it is hoped that the change due to an increase in the range of stress can be followed from the primitive condition to the limiting condition corresponding to the limiting range of stress. All the preliminary experiments bearing on the point indicate a complete absence of elastic range for repetition of all stresses of greater magnitude.

(3) *The Resistance of Materials to Repeated Tensions Between Given Limits.*—In the discussion of the paper on the "Resistance of Iron and Steel to Reversals of Direct Stress," the opinion was expressed that experiments on the effect of repeated tensions should also be undertaken. As a fairly simple modification of the alternating stress testing machine constructed for the previous work will enable such experiments to be made, it is proposed to investigate during the present year the resistance of specimens of similar forms to those machine details in which the load varies between definite limits in tension, such as connecting rod and cross-head bolts, cylinder cover studs, etc.

British Electrochemical Patents Expiring in 1907.

Nowhere is the process of evolution so vividly brought to mind as in the library of the Patents Office. Perusal of the records, while it reveals any quantity of impracticable ideas, also enables the student of such matters to trace, step by step, the way in which a fairly well-known apparatus now in use has been evolved from the complicated and expensive form in which it had its beginning. The following patents, for instance, dealing more or less directly with the electrolytic production of hypochlorite of sodium, contain many of the details to be observed in the more advanced plants of the present day. The apparatus covered by No. 5197 (Hargreaves) was, strictly speaking, intended for the production of electrolytic alkali, with the covering clause "for electrolysis generally." It consists of a vessel or tank divided into three compartments longitudinally, the two interior divisions being formed by the two plates. The negative was of wire gauze protected by a porous diaphragm, and the positive of carbon blocks. Liquid was admitted at the top on the cathode side, and filled the chamber between the two plates, draining off through the porous diaphragm to a pipe at the bottom of the tank. On the far side of the anode a pipe was provided for the escape of the chlorine gas.

This apparatus was further improved by the use of a special combined cathode and porous diaphragm, described in the specification to patent No. 5198 (Hargreaves & Bird). This was formed by the depositing of a fibrous material and a binding agent (such as asbestos and lime) on the wire gauze forming the cathode, drying the plate thus formed, and finally steeping it in a solution of silicate of soda or potash in order to convert the lime (magnesia, baryta, or other suitable substance) into an insoluble silicate. This patent would appear to indicate that the original diaphragm had been found insufficiently permanent in character.

Under No. 11,973 Messrs. Siemens Bros. & Co. and Engen F. A. Obach patented an apparatus for electrolyzing water, consisting of a cylindrical vessel, which may be of cast iron, cylindrical in form which is closed by a cover whence is hung a second cylinder reaching part of the way down the vessel. To the lower edge of this cylinder is attached the upper edge of the diaphragm of iron wire gauze, whose lower edge is fastened to a base of ceramic or other material at the bottom of the vessel. The vessel was to be charged with a solution of caustic soda or potash. Apparently the combination of a bell collector such as is commonly used in the electrolysis of water, with a diaphragm.

No. 13,336 (C. Hoepfner) is described by the inventor as "a bath with insoluble anodes of carbon, platinum, or other suitable material separated from the cathodes by a membrane resisting mechanical and chemical action." This bath is intended for the precipitation of nickel and cobalt by electrolysis. The patent covers the use of a revolving, oscillating or vibrating cathode, and of diaphragms of nitrated cotton or nitrated linen, which may be thickened and strengthened with asbestos, and mechanically protected by a grid or sieve. The apparatus is to be used with chloride solutions of the metals.

No. 18,173 (J. Hargreaves and J. Bird) relates to a cell or tank divided into partitions by plates each protected by a diaphragm. Each pair of plates forms a pocket, and between each pair is a space. At the top of this space a pipe enters the side of the tank and squirts liquid on the diaphragms on either side. The liquid penetrates the diaphragm and keeps the intermediate electrolyzing space full, draining off again at the bot-

of the cell to an outlet provided here for the purpose.

Other interesting electrical patents for the same year (1906) are Nos. 6,505, 10,584, 13,330, 13,340, 13,847 and 21,707. No. 6,505 (Messrs. Siemens Bros. & Co. and E. F. A Obach) is for structural improvements in dry cells. The cell described consisted of a zinc cylinder cemented to an insulating base, preferably of an asphalt of paper pulp. In the center of this cylinder is fixed a carbon rod surrounded by a depolarizing mixture. This consists of about 50 or 60 per cent of manganese peroxide, and about 40 or 50 per cent of plumbago, mixed with one per cent of gum tragacanth. This mixture is moulded into a hard cylinder, and placed between the central carbon and the zinc outer box. The space between the depolarizer and the zinc is filled with a mixture of 80 to 90 per cent of plaster of Paris, and 10 to 20 per cent of flour, made into a thin paste with ammonium chloride solution. Over the whole is a layer of granulated cork, and a sealing compound. A claim is also made for the method of setting the terminal in the carbon by use of an alloy expanding as it solidifies.

No. 10,584 (H. Y. Castner) is an improvement on Patent 10,040, of 1892, which relates to a process for forming an amalgam or alloy between Hg and sodium, which latter, after being deposited in the Hg, is moved with it to a second compartment, where it is separated to form caustic soda. This patent claims the cell, the rocking apparatus (a cam under one end) and the combination of the two.

No. 13,330 (A. C. Girard and E. A. G. Street) is a patent on an improved manufacture of carbons for electrical purposes. Ordinary carbons are converted into graphitic carbon by carrying them to a welding heat either by passing them, bit by bit through an arc, by passing a heavy current through the carbon, or by playing an arc on the carbon.

No. 13,340 (A. C. Girard and E. A. G. Street) is for improvements in electric furnaces in which the crucible is one pole, and one or more carbons are let down into it, completing the circuit. Claims are also made for a carbon casing for separating granular materials from the arc, and the provision, in connection with a furnace, of a magnetic field for causing the rotation of the arc or arcs.

No. 13,847 (R. A. Hadfield). A simple apparatus for ensuring greater uniformity in manganese steel. A crucible is hung on a weighing machine and manganese placed in, the steel being afterwards added from a second ladle.

No. 21,707 (E. Andreoli) is an improvement on a former patent for the production of ozone by electric discharge from numerous points, whereby the same process is made to produce illumination simultaneously with the ozone. This is effected by the use of a glass tube having inside a carbon filament and outside some serrated wires or other metallic electrode. These two wires are connected with a Ruhmkorff coil.

The Faraday Society.

At the meeting on March 19, for which four papers were announced, Dr. Lowry presided.

Mr. Nutton read the paper, prepared by himself and Mr. H. D. Law, on the "Potential of Hydrogen Liberated from Metallic Surfaces," somewhat *in extenso*.

Mr. Rhodin, opening the discussion, said the question referred to was one of the most important in connection with metallurgical work. In his own experiments he had for some time past noticed the irregularities referred to in the paper. The barometric pressure was all important, and this he did not see noted in the paper. To put it vulgarly, hydrogen could get off a —— sight easier at low pressure. (He then sketched on the board certain curves relating to the dissolution velocity of manganese bronze.. Other experimenters, such as Caspardi, and a Russian whose name he forgot, had obtained absolutely different results, which he accounted for by their working under different barometric pressures. In talking about a gaseous state, a standard temperature must be fixed.

Dr. Bjorn pointed out that the previous speaker was not alone in his observation that a difference was made by the atmospheric pressure.

Mr. Rhodin asked for the figures given by other experimenters, which Dr. Bjorn could not give.

Mr. Wilsmore made some remarks as to the influence of supertension in reduction. He also asked why ordinary cadmium was not used instead of cadmium plated on platinum.

Another speaker referred to two tables (Table 10, No. 5, and Table 4, No. 2) in the paper as showing practically the same result. In using aluminium and platinum, the aluminium became plated with platinum and then behaved as a platinum electrode.

Mr. Law said the barometric pressure was not very important. The pressure of hydrogen on the electrodes had been calculated, and shown to be enormous. There were all sorts of explanations as to the increase of the e. m. f. between the cathodes and anodes, including that of films on the cathode. The results obtained were extremely high in starting, and fell afterwards. When a reducing agent such as benzaldehyde was added the e. m. f. rose. To explain readings apparently contradictory, we suppose that metal exists in two forms, one with a high super-tension, and one with a lower. It was certainly so with iron, aluminium, nickel and platinum.

To explain the insensitiveness of zinc to arsenious hydrate, he submitted that samples of zinc occurred which arsenious oxide would not reduce. Such metal contained impurities, such as Cu, of low super-tension. If these were covered with cadmium it was all right. These experiments were to find how far cadmium would cover the platinum. With a thin coating the super-tension would be found to be that of the platinum base, and not of the cadmium. This agrees with other results, indicating that the cadmium should be thicker.

Dr. Lowry thought the problem was a difficult one, and the authors had at present only pointed out more intricacies.

The second paper on "Electrode Potentials in Liquid Ammonia," by Dr. Johnson and Mr. Wilsmore, was then briefly outlined by Mr. Wilsmore.

Dr. Lowry thought the different components of the ammonia solutions might account for the difference noted in the paper, to which Mr. Wilsmore agreed.

Mr. Rhodin then being called upon to read his paper on "The Independence of Solutes in Solvents as Manifested by Osmotic Pressure," said he was not going to read a paper so much as to ask the members a conundrum. (He drew a diagram showing a tube standing in a vessel, in which tube liquid rose by "so-called osmotic pressure.") Now by applying a condenser at the top, the evaporated liquid could be got to flow, there you have a form of natural energy.

Dr. Lowry observed the diagram represented one of the commonest forms of heat engine.

Mr. Rhodin (interrupting) said that was evident, but the problem was why the liquid rose in the tube.

Mr. Wilsmore said that Mr. Rhodin appeared to have a nomenclature of his own. He did not think the interpretation given in the paper to the term "free energy" corresponded with the meaning generally understood. He also said that the effects which the argument indicated resulted from a special value given to p in the gas law.

With regard to the statement on the last page of Mr. Rhodin's paper, he did not regard a substance as having potential energy because it had a tendency to absorb energy from the outside.

Dr. Lowry said that Van t' Hoff's theory explains the direction of motion of osmotic flow. The mechanical view of the structure of the membrane had been generally abandoned. The one of the difference in size between solvent and solute molecules had the support of Kahlenberg, Nernst and others.

Mr. Rhodin said that he wished to attack the problem as it was presented in 1887, not as it appeared in 1907. We could not explain why the rise of liquid took place except on the supposition of the absorption of outside energy. Mr. Wilsmore's

objections were only a little arithmetic, which did not touch the main problem.

Dr. Slater Price's second contribution to the study of "The Electrolytic Deposition of Zinc using Rotating Electrodes" was taken as read owing to the lateness of the evening, and the meeting broke up.

The Official Nomination for the New Council of the Faraday Society.

The Faraday Society is to be congratulated on the strength of the additions to its council. Lord Kelvin, retiring from the presidential chair, Dr. Ludwig Mond (vice-president) was asked to succeed him, but owing to ill-health was unable to comply. Sir William Perkin therefore is nominated for the presidential chair. Among the vice-presidents, Prof. Hittorf, Sir William Huggins, Prof. A. Crum-Brown and Prof. J. J. Thomson remain. The retiring vice-presidents are Sir Oliver Lodge and Lord Rayleigh, vacancies being filled by Prof. Huntingdon (who vacates his seat on the council on this promotion), Mr. R. A. Hadfield (past president of the Iron and Steel Institute) and Prof. A. Schuster.

Of ordinary members of council, Mr. Bertram Blount, Mr. W. R. Cooper, Mr. Jackson and Dr. Steinhart retire by rotation, leaving still in office Dr. Hutton, Dr. Lowry, Mr. W. M. Morrison, Mr. Swinburne and Prof. E. Wilson. New members are Mr. Beilby (returning after the statutory period of self-denial), Mr. A. C. Claudet, Mr. S. Z. de Ferranti, Mr. F. W. Harbord and Mr. Wilsmore.

To praise individual names is almost invidious, but much satisfaction is expressed at Mr. Hadfield's acceptance of nomination. Mr. Harbord has been a familiar figure and author of important papers, while Mr. Wilsmore is a hard worker among the rank and file.

Market Quotations During April.

In the chemical trade the following changes are recorded: Ammonia sulphate, increase of 5s. per ton to £35; copper sulphate has been affected by the fluctuations in the price of copper, and finally closed at £32.10. The coal tar and soda products are unchanged, but of the potash products, potassium carbonate (90-92 per cent) is 7s. per ton cheaper at £19.10.6, while, on the other hand, Montreal potash (in store Liverpool, is £1 cheaper) at £39 per ton. Shellac has been in good demand, closing at £10.19 per cwt.

In the metal market, the early part of the month was marked by the decline in the price of copper to £92.10 per ton on April 3. By the 9th it had rallied to £99.10, receded to £93.5 by the 15th, subsequently rising steadily to £104.10 by the 30th. Tin moved somewhat similarly, receding from its opening price of £185.15 to £181.5 on April 4, rallying by the 10th to £186.17.6, and after weakening to £184.2.6 rising steadily to £195. Lead has been rather more varied than usual, starting at £20 it touched £20.17.6 on April 22, fell back to £20.5 by the 25th, and closed at £20.12.6.

The upward movement in iron prices is very pleasing. Cleveland pig iron which opened at 54s., closed at 58s.3d. per ton, the highest price of the year. Scotch pig iron advanced from 61s. to 65s.9d., and hematite closed at 76s.9d.

London, May 4, 1907.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Silicon as Reducing Agent for the Production of Chromium, Tungsten, Etc., and Their Ferro Alloys.—F. M. Becket, 854,018, May 21, 1907. Application filed Sept. 23, 1905. (Assigned to Electro Metallurgical Co.)

The patent refers to the use of metallic silicon as reducing agent in the production of chromium, tungsten, molybdenum and vanadium and the alloys of these metals with iron or nickel. The special object is to produce these metals or alloys low in carbon and low in silicon. The process will be understood from the description of the manufacture of ferrochrome from chromite. As the chromium in chromite exists as chromium sesquioxide, Cr_2O_3, and practically all the iron as ferrous oxide FeO, the following reactions take place:

$$2Cr_2O_3 + 3Si = 4Cr + 3SiO_2$$
$$2FeO + Si = 2Fe + SiO_2$$

A fair commercial grade of chromite contains 52 per cent Cr_2O_3 and 16 per cent FeO, and 100 pounds of this ore will therefore require, according to the above reactions, 17.7 pounds silicon for complete reduction of the chromium and iron. A representative analysis of ferrochromium made by this method is as follows: Chromium 71.00 per cent, iron 28.40 per cent, carbon 0.50 per cent, silicon 0.10 per cent. It is advantageous to use the silicon in a fairly fine state of division, and the metal is generally crushed so that it will all pass a 10-mesh screen. However, the state of division of the silicon depends on the scale of the operation. The use of a basic flux in the production of ferrochromium is not essential although advantageous. Most commercial chromites contain from 8 to 15 per cent Al_2O_3 and 8 to 15 per cent MgO. These materials serve as basic flux for the silica present in the ore and for that produced by oxidation of the silicon; but the proportions are such that to maintain this slag fluid for tapping, a higher temperature is necessary than that required for complete reduction of the chromium and iron oxides by silicon. In the case in which very low silicon content is required in the alloy (less than 0.2 per cent), chromite is used in very slight excess above the theoretical proportion; while in the case in which a silicon content as high as 1 per cent is permitted the silicon is used in very slight excess. In the second case the yield of metal from the ore is slightly higher. The inventor carries on the reduction continuously in the electric furnace in which the current passes through a molten bath of a mixture of ore, silicon and flux, and from which part or all of the metal or slag may be withdrawn as desired. He feeds the mixture to a bath which is constantly maintained at a temperature higher than that necessary to cause some reaction. The use of silicon as a reducing agent is claimed to have the following advantages over the use of aluminum: a relatively large weight of metal reduced per unit weight of reducing agent; the comparative ease of finely dividing silicon; the fact that the reaction proceeds more quietly and with less loss of material; finally silicious ores which are relatively inexpensive may be successfully used.

Silicon as a Reducing Agent for Producing Metals and Alloys from Sulphides.—Fred. M. Becket, 855,157, May 28, 1907. Application filed March 5, 1907.

While the process is applicable to sulphide ores, concentrates, matte, etc., in general, it is stated to have particular advantages for the production of molybdenum and vanadium from their sulphide ores, according to the equation, in the case of producing molybdenum from molybdenite

$$MoS_2 + Si = Mo + SiS_2$$

Commercially pure ferro molybdenum or ferro-vanadium or the corresponding nickel-molybdenum or nickel-vanadium alloys may be produced by smelting in an electric furnace a

mixture of molybdenum or of vanadium sulphide, with a silicon alloy such as ferro-silicon or nickel-silicon, the alloy being preferably used in approximately the proportions required to supply sufficient silicon to unite with the sulphur of the sulphide. It is not essential that the proportion of silicon to sulphur should be precisely that indicated by theory, for in case a product very low in silicon is required the sulphide should preferably be used in excess of such proportion; whereas if a certain proportion of silicon is permissible in the product an excess of the silicon or silicon-bearing reducing agent may be used. The operation is preferably rendered continuous by adding fresh portions of the charge from time to time and withdrawing the product as desired. By smelting the charge in a close chamber and protecting the products from oxidizing influences the sulphide of silicon may be collected, but in open smelting furnaces both of the constituent elements of the sulphide unite with oxygen, yielding silica in a state of minute sub-division and sulphur dioxide; these products may be collected and utilized. The substances to be treated by the process must be finally sub-divided.

Electrolytic Processes.

Electrolytic Production of Sodium.—F. von Kuegelen and G. O. Seward, 850,376, April 16, 1907. Application filed May 4, 1905.

It has been proposed to produce sodium by electrolyzing fused sodium chloride with a molten anode of a heavy metal, as silver or copper, so that the chlorine liberated at the anode forms a chloride with the heavy metal. The trouble which has always been experienced with such processes is that the chloride thus formed did not remain at the bottom of the

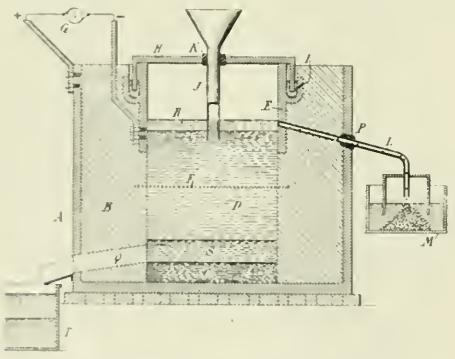


FIG. 1.—ELECTROLYTIC PRODUCTION OF SODIUM.

electrolyte but soon began to rise, with a resulting deposition of the heavy metal, instead of sodium, on the cathode. The present inventors design their cell so that all disturbing factors which would cause the chloride to rise upwards are avoided. Since the chloride has a higher specific gravity it has a natural tendency to remain at the bottom. The cathode is located in the upper part of the electrolyte as remote as possible from the heavy anode and the chloride formed at the anode is periodically removed. A diaphragm of foraminous metal such as iron wire cloth is interposed between the cathode and the chloride of the anodic metal whereby the latter is confined beneath the diaphragm. The use of such a metal diaphragm is rendered possible by the absence of free halogen or other electronegative agents which would otherwise corrode and destroy the metal. The inventors also point out that it is necessary to construct the cell of a sufficiently large diameter.

The cell is shown in Fig. 1. A is an iron cathode having a lining B of fire-clay or magnesia, etc., containing at the bottom a pool of molten lead C which forms the anode. Above this anode flows the body of the molten sodium chloride to be electrolyzed D, and at the upper part of the electrolyte it comes in contact with an annular cathode E of cast iron forming part of the outer wall of the cell. F is the diaphragm which may consist of one or more layers of iron wire cloth. The cell is hermetically sealed by an iron cover, through which projects a feed pipe J for introducing fresh electrolyte, its lower end being sealed in the electrolyte. The sodium R formed flows on the electrolyte and is discharged through the tube L into a vessel M containing oil. S represents the lead chloride formed which is at intervals run off through the tap hole Q.

Electrolytic Cell.—Anson G. Betts, 850,127, April 16, 1907. Application filed May 11, 1904.

This patent refers to the construction of an electrolytic cell for such purposes in which the anolyte is kept separate from the catholyte. It is said to be particularly adapted for the electrolysis of ferrous sulphate, copper sulphate solutions for the production of metallic copper and ferric sulphate. The tank 1 in Fig. 2 (which shows a vertical longitudinal section and a vertical cross-section) is divided into a series of compartments by means of transverse partitions 3, which are separated one from another along their bottom edges by sills 4, resting on the bottom of the tank, and along their vertical edges by uprights 5 of the same width as the sills 4 and seated in notches in the sills. Each sill and the pair of uprights seated thereon constitute a spacing frame adapted to separate from one another by a definite distance the two partitions on opposite sides thereof. The sills 4 may extend the whole width of the tank; but the partitions are of less length than the interior width of the tank, and the uprights 5 are erected in line with the vertical edges of said partitions, thereby leaving a pair of longitudinal chambers 7 and 8, extending along the opposite sides of the tank from end to end thereof. The alternate compartments formed by said partitions and spacing frames are in communication with the longitudinal chambers 7 and 8 by means of inlet-apertures 10, formed in the upper portion of the uprights adjacent to the chamber 7, and outlet-apertures 11, formed in the lower portion of the uprights adjacent to the other chamber 8. The other compartments are closed to both chambers 7 and 8. The compartments closed to the chambers 7 and 8 are adapted to contain the anolyte in contact with the anodes 12, while the other compartments, as well as the chambers 7 and 8, are adapted to contain the catholyte in contact with the cathodes 13.

The partitions separating the compartments are made of wood having numerous perforations which are filled with wads of asbestos. A pipe 18 leading from a supply of air under pressure, is projected nearly to the bottom of the tank, and the air escaping from the lower end of the pipe and rising through the catholyte causes it to rise to a level higher than the general level of the catholyte in the remainder of the vat and to overflow the bottom of the aperture 16, through which it passes into the neighboring chamber 7, tending to raise the level of the catholyte in that chamber. The catholyte thus caused to flow into the chamber 7 is taken from the chamber 8 through the bottom opening 11 in the adjacent upright at the end of the compartment having the well, through which compartment it passes beneath the inserted partition 15 into the well. The result of this operation is a constant tendency to raise the level of the catholyte in the chamber 7 and reduce its level in the chamber 8, causing a gravity flow of the catholyte through the upper apertures 10 into the respective cathode compartments and through the lower apertures 11 out of said compartments.

For the purpose of securing circulation of the anolyte along the opposite sides of the vat a pair of troughs 19 and 20 are provided, supported upon horizontal cross-pieces 21, interposed between the vat walls and the ends of the partitions and the spacing uprights. The trough 19 is connected with the bottom of each anode compartment by means of a siphon tube 22, which extends up over the spacing upright adjacent to the

trough, and in like manner the trough 20 is connected with the upper end of each anode compartment by a siphon tube 23, which extends up over the neighboring spacing upright. At one end of the vat is provided an exteriorly-located well 24, with the lower end of which the trough 19 is connected by means of a siphon tube 25, and with the upper end of which the trough 20 is connected by means of a tube 26. A pipe 27 leading from a supply of air under pressure is projected nearly to the bottom of the well, and the air thereby deposited near the bottom of the well rises in bubbles through the anolyte, raising the level of the same in the well above the general level of the anolyte and causing a flow through the tube 26 into the trough 20. This operation tends to continually lower the level of the anolyte in the trough 19 and to raise its level in the trough 20, causing a flow through the siphons 22 and 23 from the trough 20 into the upper ends of the respective anode compartments and through the siphons 22 from the lower ends of the anode compartments back into the trough 19.

The cathodes 13, which are in the form of plates, are suspended by means of hooks 30 from metallic cross-bars 31. The anodes 12 are in the form of rods depending from metal cross bars 36 of a carriage 37, mounted upon rollers 38, adapted to

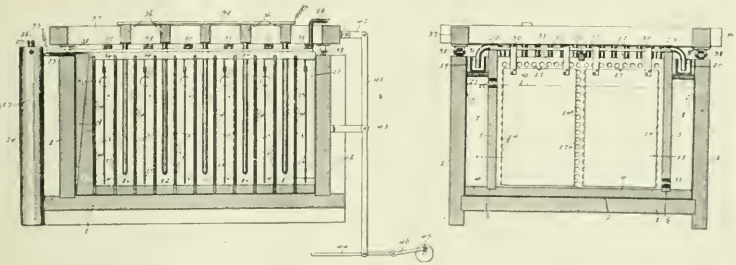


FIG. 2.—DIAPHRAGM CELL.

rest upon and travel longitudinally along the top surface of the side walls of the vat. To-and-fro movements can be imparted to the anode carriage by means of the lever 41, and it is stated that these movements materially diminish polarization and increase the life of the anodes. A reciprocating motion of 1 inch amplitude has been found to give good results. For the electrolysis of copper iron sulphates, the catholyte may consist of an aqueous solution containing about 4 per cent of iron in the form of ferrous sulphate, 2½ per cent of copper in the form of copper sulphate, and 2 per cent of free sulphuric acid, and a suitable anolyte may consist of an aqueous solution containing about 3 per cent of iron in the form of ferric sulphate, 1 per cent of iron in the form of ferrous sulphate ¾ per cent of copper in the form of copper sulphate, and 2 per cent of free sulphuric acid, the same being substantially free from halides. By the term "halide" is meant the simple combination of a halogen or cyanogen with an element, ammonium or equivalent.

Diaphragm for Sodium Chloride Electrolysis.—Leo H. Baekeland, 855,221, May 28, 1907. Application filed March 10, 1906. Assigned to Development & Funding Co.

This patent is evidently an outcome of Dr. Baekeland's work in developing the Townsend cell on a large scale—an account of the Niagara Falls plant using this process being given by Dr. Baekeland on another page of this issue. The present patent refers to a new preparation of the diaphragm separating the anolyte from the catholyte. To the surface of a base consisting of woven asbestos fabric, commonly known as asbestos cloth, a permeable coating, paste or paint, is applied, consisting of an oxide of iron such as Venetian red or Indian red, asbestos powder or equivalent filling of ferric or ferrous hydroxide. This paint may be prepared by precipitating 400 cc. of ferric chloride solution having a specific gravity of about 1.4 by an excess of caustic soda, and adding to the resulting alkaline mass and thoroughly incorporating therewith about 500 grams of ferric oxide and 1,200 grams of asbestos powder, together with sufficient water to convert the mixture into a rather thick paint. Such mixture is uniformly spread over the asbestos cloth and permitted to dry thereon, when the diaphragm is ready for use. The excess of caustic soda above referred to is desirable, as it distinctly aids by its cementing effect in the production of a coherent and durable coating. Ferrous hydroxide is the equivalent of ferric hydroxide for this purpose, inasmuch as it becomes wholly or partly converted into ferric hydroxide during the drying of the diaphragm. It possesses over ferric hydroxide the advantage of economy, since it is readily prepared by dissolving scrap iron in commercial muriatic acid and precipitating the resulting ferrous chloride solution.

Electrolytic Production of Aromatic Alcohols.—Charles Mettler, 12,654, May 21, 1907. Application filed March 20, 1906.

The process refers to the reduction of aromatic esters to alcohols, for example, of the ethyl ester of benzoic acid to benzyl alcohol. The aromatic ester is electrolytically reduced at a metal cathode of high cathodic tension, for example, at a lead cathode. The ester is dissolved in concentrated sulphuric acid diluted with water, or alcohol or acetic acid. In lieu thereof an aqueous alcoholic solution of hydrochloric acid can be used, etc. The product consists partly of benzyl alcohol and partly of benzylethylether, which latter boils at a temperature of 185° C. The invention is not limited to the various esters of benzoic acid but relates generally to the whole class of aromatic esters. The relative quantities of alcohol and ether produced vary in different gases and appear to depend on the constitution of the compound being reduced.

Plating of Ceramic Vessels.—S. Heller and C. Baumgartl, 850,753, April 16, 1907. Application filed August 5, 1905.

A metal coating is first produced by melting onto the ceramic article finely-divided gilt enamel tombac, together with a mixture of enamel and calcined borax. Gilt-enamel tombac is a preparation or alloy which is fire-proof up to 1,200° C. It is practical to mix two parts of enamel with one part of calcined borax and one part of finely-divided gilt-enamel tombac. Gilt-enamel tombac may consist of substantially three parts of copper, one part of zinc and one-eighth part of gold. This mixture is put onto the ceramic objects to be coated and is burned in, as, for example, in a muffle at a temperature of 800° C. After the article has cooled off the surface of the fused or burned-in coating is ground, abraded or polished, so that a clear metallic surface appears. The article is then placed in a galvanic bath, in which electrodeposition takes place, so that thereby the outer metallic envelop is plated, thickened and strengthened to any suitable degree. The article is then ground and polished. The metal coating thus produced adheres with exceeding firmness to the base.

Electrolytic Wool Washing and Cleansing Apparatus.—G. D. Burton, 854,028, May 21, 1907. Application filed Aug. 11, 1905. (Assigned to American Electrical Process Co.)

Mechanical details of construction of a vat for electrolytically washing and cleansing wool and other textile substances, such as cotton, hair, flax, etc. The patents refer

reference to details of construction of the vat with a revolving drum for agitating the electrolyte, but the nature of the electrolyte is not stated.

Batteries.

Storage Battery. E. Sekal, 852,464, May 7, 1907. Application filed May 4, 1906.

During charging a lead cell, the concentration of the sulphuric acid electrolyte increases because SO_4 is taken out of the plates into the electrolyte. Reversely during discharge the concentration of the electrolyte decreases. Since these changes are the result of the chemical reactions directly at the active surface, that is, in the pores of the plates, the concentration increases rapidly within the pores during charge far more rapidly than in the body of the electrolyte outside of the pores. During discharge the concentration decreases rapidly within the pores and far more rapidly than in the body outside. It has long been recognized that these facts are at the bottom

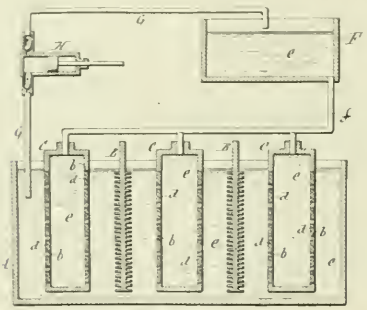


Fig. 3.—STORAGE BATTERY.

of many characteristic features and troubles of storage batteries. They explain, for instance, the drop of e. m. f. during discharge and the greater drop and smaller capacity at higher discharge rates. The present inventor endeavors to overcome these difficulties by artificially maintaining the concentration of the electrolyte uniform throughout the whole cell. For this purpose he pushes or forces the electrolyte through the electrodes during charging and discharging. The construction is shown in Fig. 3, where B are the negative electrodes and C the positive electrodes. The latter are constructed in the form of hollow skeleton frames or grids with openings *b* in the walls which contain fillings *d* of lead peroxide. The space within the hollow electrodes as well as the space in the jar which surrounds the positive and negative electrodes is filled with the electrolyte *e*. The level of the electrolyte on the inner side of the hollow electrode is higher than that on the outer side thereof, so that the force of gravity will have the effect of pusing or forcing the electrolyte from the inside of the hollow electrode outwardly through the porous fillings *d* thereof into the space of the jar around the outside of the hollow electrode. In order to maintain this difference of level means are provided for withdrawing part of the electrolyte from the jar to a supply tank F, from which it is returned into the hollow positive electrodes.

Storage Battery Plate.—Lamar Lyndon, 852,569, May 7, 1907. Application filed June 3, 1905.

The object is to provide an envelope for storage battery plates through which electrolyte may pass freely, while it is impervious to solid material, even if in a very fine divided state, and held in suspension in the solution. Two different diaphragms of porous coarse-grained wood are united at the sides and at the lower edge with hard rubber or celluloid framework, the whole forming a thin box which is slipped over the plate. If the upper edges of the box be above the surface of the electrolyte it is unnecessary to seal the top.

Storage Battery Electrode.—T. A. Edison, 854,200, May 21, 1907. Application filed March 30, 1905.

This patent relates to a method for making a spongy honeycomb integral mass of metallic cobalt, or cobalt-nickel alloy, for use as electrode in the Edison storage battery. Scales, flakes, films or foils of cobalt or of cobalt-nickel alloy are produced by electro-deposition, and are carefully annealed below the welding temperature in an inert gas such as hydrogen. The two pocket sections of the well-known Edison construction are now engaged together and securely held by crimping the edges of the outer section around the inner section. The upper end of these pockets is left open for the introduction of the material into each pocket. For this purpose a great number of pockets are assembled, and the metallic flakes or foils are introduced into them through a vibrating screen from above. The amount introduced at each operation is carefully regulated and a definite uniform tamping pressure is applied afterwards. When a pocket has been thus loosely filled with conducting films or flakes it is closed at its upper end and introduced within its supporting grid. The latter is now subjected to the welding temperature in a hydrogen atmosphere whereby the flakes are welded together and to the walls of the pockets. As a result, Edison obtains within each pocket a fine, quite soft, pithy, readily compressible sponge of metal or alloy, presenting innumerable cells all connected together. The active material is now introduced within the sponge-like mass by dipping the electrodes successively in a saturated solution of the active material with alternate evaporations, so as to deposit the active material in layers within the many cells.

Battery Grid.—Joseph Bijur, 854,326, May 21, 1907. Application filed Aug. 14, 1906. Assigned to General Storage Battery Co.

The plate consists of a frame with ribs made of antimonial lead, and into the open spaces between frame and ribs are inserted the grids of pure lead for the active material. The grids and the frame are united according to the process of Mr. Bijur, which consists, broadly, in superheating a globule of lead or alloy to a degree at which it is capable of superficially fusing the surfaces it touches and in depositing it in that condition in a suitable place for uniting the parts of the battery plate.

Flexible Connection for Storage Battery.—B. Ford, 854,817, May 28, 1907. Application filed Sept. 24, 1904.

The object is to provide an acid-proof flexible connection for connecting one storage battery with another or with the line, etc. It comprises a connector with an insulating cover and an enlarged bare end and a non-corrosive lug cast onto the enlarged end and adjacent portions of the cover.

Miscellaneous.

Drying Electric Cables.—W. B. Hale, 851,747, April 30, 1907. Application filed March 12, 1906. Assigned to Western Electric Co.

The common method of drying cables involves the passage of a strong current through the conductors to heat the cable sufficiently to vaporize the moisture. The vapor is then withdrawn by means of an air pump applied to the end of the cable. The present patent refers to a modification in which a potential difference is established between different conductors of the cable sufficient to cause a flow of current through the moisture remaining in the insulation which separates the two conductors, and the moisture is thereby electrolytically decomposed. As decomposition progresses the insulation resistance gradually increases, and the potential difference is raised but not, of course, beyond the dielectric strength of the cable. To send sufficient current through, it may be necessary to temporarily reduce the resistance of the insulation by means of heat, which may be developed either in the conductors of the cable by

electric currents or in the dielectric itself by the application of an alternating e. m. f.

Treament of Fish Oil.—A. de Hemptinne, 852,662, May 7, 1907. Application filed March 17, 1906.

The object is to eliminate the characteristic and disagreeable odor of fish oil and to make at the same time the oil thicker. This is accomplished by submitting the oil to the action of a silent electric discharge in an atmosphere of hydrogen. The hydrogen is not absolutely necessary, but it accelerates the process and renders it more efficient. The hydrogen is fixed by the oil so that at intervals fresh hydrogen is supplied to the apparatus during operation. The thickening of the oil is also due to the conversion of the oil under the influence of the silent discharge. The process is carried out in a revolving drum containing alternately positively and negatively charged cross-sectional plates separated from each other by plates of glass.

RECENT METALLURGICAL PATENTS

IRON AND STEEL.

Substitute for Charcoal Iron.—R. C. Totten (854,126, May 21, 1907) endeavors to produce from coke or coal iron—that is, pig metal smelted with coke or anthracite coal—a casting iron suitable for the manufacture of chilled castings or the like which have heretofore been made from charcoal iron. For chilled rolls, chilled car-wheels, etc., the use of charcoal iron has been considered necessary on account of the contents of combined carbon. The inventor introduces the combined carbon by means of spiegeleisen, which contains a large proportion of combined carbon, while the manganese present aids the combined carbon in importing chilling properties to the iron. His cast metal consists of coke or coal-iron and spiegeleisen, the composition containing at least ½ per cent of combined carbon and manganese at least 1 per cent in excess of the combined carbon. For example, if the combined carbon present is 1 per cent the manganese will be 2 per cent or over. The casting metal so produced can be made at lower cost than the charcoal pig iron usually employed for the making of such castings, as the cost of the ordinary gray coke or coal iron is much lower than the cost of charcoal iron, and though the cost of spiegeleisen is higher than that of charcoal iron the small proportion usually employed does not materially increase the cost of the casting produced, the actual cost of the composition being less than the ordinary charcoal pig iron.

Ferro-Molybdenum.—H. W. C. Annable, of the Ferro-Alloys Syndicate, of London (852,920, May 7, 1907), patents the following process for producing ferro-molybdenum from molybdenite. The latter is an ore which consists essentially of sulphide of molybdenum. It is ground and mixed with sodium carbonate or sodium hydrate or a mixture of both, and the mixture is heated to a temperature just above the melting point in a reverberatory furnace; the fire gases and products of combustion carrying an excess of oxygen. The whole bath is uniformly heated to a temperature just above the melting point, and the effect of the excess of oxygen in the gases is to oxidize the sulphur and molybdenum and to cause them to combine with the alkali. The charge thereby becomes a mixture of sulphate of sodium, molybdate of sodium and free sodium hydroxide mixed with the unattacked portion of the ore. The charge after having been withdrawn from the furnace is crushed and thrown into hot water, which dissolves the sulphate of sodium, the free sodium hydroxide and the molybdate of sodium. From this hot, strong solution the molybdenum is precipitated by means of a solution of an iron salt, such as ferric chloride, ferric sulphate, ferrous chloride, ferrous sulphate or mixture of these. The precipitate consists of molybdate of iron which will be free from sulphur if the process is carefully carried out. The molybdate of iron is dried and reduced to ferro-molybdenum by either of the following two ways: The first method is to heat the molybdate of iron to a low red heat in a furnace without admixture of carbon and then reduce it to ferro-molybdenum by a current of a suitable gas, such as coal, producer or water gas, the heat being maintained until the gas evolved ceases to contain products of deoxidation. The ferro-molybdenum is then allowed to cool in contact with the reducing gas. The second method consists in mixing the molybdate of iron with sufficient pure oxide of iron to produce after reduction a ferro-molybdenum which is fusible at a white heat (from 1,300 to 1,400° C.), and with sufficient carbonaceous matter to reduce the oxides. This process may be carried out in an apparatus containing two refractory receptacles, one above the other, and heated to white heat. The upper receptacle contains the mixture under treatment. From a hole in its bottom the reduced ferro-molybdenum drops into the lower receptacle which contains oxide of iron. The ferro-molybdenum percolates through the iron oxide and is obtained practically free from carbon.

ZINC.

Reduction Furnace.—The rotary motion which is such a characteristic feature of many inventions of C. G. P. De Laval, of steam turbine and cream separator fame, is found in the same inventor's zinc reduction furnace shown in Fig. 1. The zinc ore together with materials necessary for carrying out the reactions is introduced into the furnace chamber in which the charge is subjected to a rapid rotation by means of a rapidly rotating gas or air current. If the zinc ore consists of unroasted sulphide of zinc the charge is composed of sulphide of zinc, carbon and iron ore, whereas the gas current consists of carbon monoxide or air, mixed with carbon in a proportion so as to form carbon monoxide in the furnace chamber. If the sulphide of zinc is roasted, iron ore need not be added. If the material to be treated consists of zinc oxide, carbon is added for its reduction, whereby the gas current preferably consists of carbon monoxide to avoid reoxidation of the zinc. If zinc oxide is to be produced an air current is employed for obtaining the oxidation. The charge is introduced continually and uniformly in the upper part of the furnace chamber, for instance, through the hopper 2, whereas, simultaneously carbon monoxide or air mixed with carbon in a proportion so as to form carbon monoxide within the furnace chamber is introduced tangentially and with great velocity by pressure or suction through the pipe 5. Owing to the tangential direction in which the air or gas current is introduced the current will follow the circular

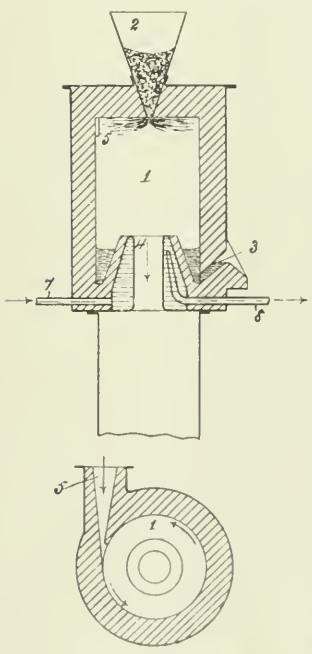


FIG. 1.—ZINC FURNACE.

furnace wall and is thus brought into a rapid rotation, which is also imparted to the charge introduced. In or near the center of the bottom of the furnace chamber is an outlet 4 for the gases developed during the process. The gases will flow in a spiral direction during their way from the furnace wall, which they follow at the inlet, to the outlet in or near the central line of the furnace. The charge on the contrary is subjected to the centrifugal force during the rotation and moves from the central line of the furnace to the circumference of the same, during which motion the chemical processes are carried out. The charge and air or gas current will therefore move in opposite directions toward one another, owing to which the processes are carried out rapidly and completely. The crude ore and slag produced during the process gather on the furnace wall and flow down to the lower part of the furnace, from which they are drawn off through the outlet 3. The developed zinc gases or the zinc oxide fume follow the gases out through the outlet 4, and are condensed or gather in any convenient manner. In the construction shown on the drawing the outlet is formed with a hollow wall and which is cooled by means of a water current circulating through the pipes 7 and 8.

Filling Zinc Retorts.—J. D. James (851,668, April 30, 1907) proposes a mechanical method of filling zinc retorts by blowing the zinc ore, etc., with the aid of a jet of "fluid," under strong pressure, into the retorts, the jet being of such force as to pack the charge firmly and evenly within the whole cross-section of the retort.

Precious Metals.

Continuous Boiling-Out Still.—J. T. Ludlow and D. Mosher (853,980, May 21, 1907) patent details of construction of an apparatus for use in the ammonia-cyanide process of treating copper, nickel or zinc ores containing precious metals. The idea is first to transform the metals such as copper, nickel or zinc, present in whatever form in the ore, into a condition soluble in ammonia solutions of varying strengths; leaching such ammonia, copper, nickel or zinc solutions from the ore by known methods, and under conditions which will, as much as possible, prevent loss of ammonia; then by boiling the ammonia solution of metal hydroxide, carbonate or sulphate the metal is precipitated as oxide at the boiling point of water, and is thereby practically rendered anhydrous. The ammonia passes over as vapor to be reabsorbed by cold water or cold boiled out waste solution for use with slight loss over and over again. The apparatus described in the present patent is intended to accomplish the metal oxide precipitation and ammonia recovery in an economical and continuous manner. The chief feature is a boiling-out still, having such connections that during the process of boiling out to liberate the ammonia from the solution and to precipitate the metal oxide, the metal oxide ammonia solution is supplied to the still and the waste hot boiled-out solution is discharged from the still in a continuous flow or operation. The waste hot boiled-out solution from the still passes through a "heat interchanger," and gives up its heat to the incoming metal oxide solution which passes through the interchanger to the still; the ammonia gas meanwhile passing from the still to the condenser and absorber to be returned to the supply of metal solvent for use over and over again.

Alloys.

Copper Zinc Alloy.—G. E. Buttenshaw (854,462, May 21, 1907) patents an alloy suitable for use in the construction of marine engines, pumps, sea valves, torpedo tubes and the like, which are brought into contact with salt water, and which shall not be liable to oxidize or set up galvanic action in the presence of iron and steel. The alloy consists of the following metals in the stated approximate proportions by weight: Copper 40 to 43.19 per cent, zinc 41 to 43.86 per cent, nickel 10 to 10.20 per cent, lead 1 to 3.5 per cent, phosphor tin 1 per cent, aluminium 0.15 per cent.

Assaying.

Pouring Mould. The object of the construction of a pouring mould patented by Mr. John J. Bailey (850,811, April 16, 1907) is to facilitate the separation of the metallic portion of the contents of the mould from the slag. The construction is shown in Fig. 2, the upper diaphragm being a top plan and the lower one a longitudinal section. When in use the body of the mould rests on the base plate 6. The body of the mould is

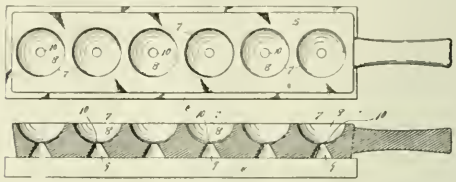


Fig. 2.—Pouring Mold.

composed of a series of receptacles 7, each of which consists of two compartments, 8 and 9, of which 8 is cup-shaped and 9 cone-shaped; the two compartments communicate with each other through a small orifice 10. After the ore from which the values are to be extracted has been mixed with the necessary flux and reduced to a molten condition it is poured into the receptacle 7. The metallic portion to be separated from the gangue is heavier and passes downwardly into compartment 9, while the lighter gangue occupies the compartment 8. As soon as the contents of the receptacle become cold it is only necessary to tap the contents of 8 with a hammer in order to cause the metallic contents of 9 to break off and drop out of its compartment. In this way more nearly an exact separation of the metal from the gangue is effected than can be accomplished when the molten mass is poured into a single compartment.

SYNOPSIS OF PERIODICAL LITERATURE

A Summary of Articles Appearing in American and Foreign Periodicals.

Electric Furnace.

Electric Furnace Reactions Under High Gaseous Pressures.—A brief summary has just been published in the *Proceedings* of the Royal Society of the investigations of Dr. R. S. Hutton and Mr. J. E. Petavel with their high-pressure electric furnace. (See *Electrochemical Industry*, 1903, I., 244-245.) The following will serve as an indication of the contents of the paper which it is hoped will soon appear in extenso. Two steel chambers of 20 and 2 liters capacity, respectively, provided with valves, windows and insulated electrode holders have been constructed and employed at working pressures up to 200 atmospheres. Inside these pressure vessels any desired arrangement for arc or resistance heating is mounted. Apart from the influence of pressure, which was the primary object of the investigation, special attention was paid to the effect of the nature of the gaseous atmosphere upon the reactions. Some measurements were made of the electrical constants of carbon and metal arcs in different gases at high pressures and the rate of oxidation of heated metals was also considered. With a charge of 10 kilos. of lime and carbon the preparation of calcium carbide was studied in atmospheres of carbon monoxide, coal gas and hydrogen under reduced and high pressures. Contrary to expectation no unfavorable influence of carbon monoxide upon the yield was noticeable, the back reaction being limited to the surface. Silica fused under pressure exhibits a marked decrease in vaporization but no appreciable increase in fluidity and transparency. The production of carborundum under pressure is much limited owing to

this decreased volatility of silica. The authors as a result of a long detailed investigation of the reduction of alumina, conclude that this oxide is reducible by carbon at all temperatures above the melting point, bu. the metal is set free in the form of vapor and can only be collected if it be protected from reaction with carbon monoxide. Having overcome the difficulties of maintaining an electric arc in highly compressed air it is shown that the production of oxides of nitrogen exhibits an increased efficiency attributable to pressure.

COKE.

The Determination of the Quality of Coke from its Appearance.—The basis for determining the quality of coke as a rule is, of course, a chemical analysis, though it is a matter which is very frequently left to judgment by the eye, and it is possible for experienced observers to obtain considerable accuracy. In *Glückauf* of March 9, 1907, Mr. Thau details a series of observations, based upon analytical data, of the quality of coke when judged by the eye only. The author concludes by summarizing the following characteristics for coke with a high content of ash: (1) Impurities consisting of incombustible substances in the fracture; (2) Dark, sandy appearance, without a great abundance of pores; (3) Exceptionally high weight; (4) The edges of the pores appear with metallic luster in the fracture. The following are characteristics for a high content of volatile ingredients: (1) The coke falls without sound when dropped upon a hard surface; (2) It has a black appearance without luster; (3) It contains small blue-black spots in the fracture, due to uncoked coal; (4) It appears in thick pieces which break apart easily; (5) The interior of the pores is deep black and the edges have a tarry luster.

It is easy to ascertain a high content of water if a small piece of coke is knocked off and the pores are seen to be filled with water under the magnifying glass. It is also possible to notice a cold feeling in the hand when a piece of coke is gripped firmly. If the content of water amounts up to 6 per cent it is absorbed by the pores, so that it is hardly or scarcely noticeable. The analysis for ascertaining the sulphur content of coke as carried out by the author is as follows: 11.5 grams of pulverized sodium peroxide and 0.7 grams of finely powdered coke, or 16 grams sodium peroxide and 0.7 grams of coal are weighed out into a steel, or, better, a nickel crucible of about 50 cc. contents. Both ingredients are mixed thoroughly and the crucible is put upon a small tripod into a beaker in such a manner that there is 1 cm. distance between the bottom of the crucible and that of the glass. The beaker is then filled with distilled water, so that the crucible is standing in the water up to about its middle. In the cover of the crucible there is a small hole, through which an incandescent wire is introduced in order to ignite the contents of the crucible. After about three minutes the crucible is put on its side so that the contents can dissolve. After that the crucible lid and tripod are well washed off and removed from the beaker. So much hydrochloric acid is then added that the solution is just acid. This can be recognized when the acid is added slowly by the appearance of a bright green color and a complete coloring up of the liquid. The solution is then boiled and a few drops of ammonia barely in excess are added, and then 15 cc. of barium chromate (solution, 23 grams barium chromate, 80 cc. concentrated hydrochloric acid, 920 cc. distilled water). At this point one has to be sure that ammonia is in excess, and that the solution is boiled until no smell of ammonia is recognizable, and no longer, and until the solution has been concentrated to a quantity suitable to titration. The solution is then filtered, the precipitate boiled with water, and 1 gram of potassium iodide is added to the filtrate. It is then cooled off to 30° C., 5 cc. of hydrochloric acid are added and a little starch as indicator, and the solution is titrated with a 1/10 normal solution of sodium thiosulphate. The main point in this analysis, of which several can be made in an hour, are two, namely: (1) The solution must be very well filtered —the filtrate must be absolutely clear; (2) The preparation of the barium chromate solution is of great importance because the barium chromate which can be bought in the trade contains mostly an excess of barium chloride or of potassium chromate. It is therefore better to make this preparation oneself and to wash it well, inasmuch as a small excess of either one of these substances influences the result of the analysis.

Formation of Prussian Blue in the Ammonium Sulphate from Coke-Oven By-Products.—Many coke-oven plants experience considerable trouble on account of the blue coloration of the ammonium sulphate, which, though it is not of any consequence as far as the quality of the salt is concerned, yet affects the selling price to a great extent, as the blue-colored salt is not as easily disposed of as the pure white. Much trouble has been experienced in overcoming this discoloration of the salt, and some of the plants turn out hardly anything else but salt of this description. Mr. Thau, in *Glückauf*, of Jan. 26, 1907, investigates the causes of the formation of this blue salt, which is due to the formation of Prussian blue. This Prussian blue makes its appearance wherever cyanogen from ammoniacal gases or from the condensed ammonia water is separated out and forms a compound with the iron of the walls of the tubes or apparatus. This happens especially in such cases in which an excess of crude ammonia gas is employed for cooling purposes. It happens in the rarest cases that the distillate is still blue in the distillation apparatus unless very cold ammonia water is introduced. In order to prevent this, therefore, a good preliminary heating of the ammonia water is a prime requisite. The place where the Prussian blue compound is formed in most cases is at the junction of the pipe between the distillation apparatus and the saturator. In order to prevent its cooling the pipes should be well insulated, and should rise more towards the saturator so that any condensed water which may be present can flow back into the apparatus. The valves should also be located as close as possible to the junction points of the pipes so that it is not necessary to keep steam in long lengths of pipe, and thus give it opportunity for distilling. A further place where the formation of the blue cyanogen compound takes place is the draw-off pipe line for the cyanogen vapors of the saturator. If any or all of these causes are seemingly excluded the formation of the discoloring compound is evidently due to faulty manipulation of the apparatus. It should be such that in no case the ammonia vapor becomes too cold, not below 100° C., as an excess of crude ammonia gas can already cause the formation of Prussian blue in the pipe line below a temperature of 98° C. The author gives the following rules for the utilization of the blue salt if it has been formed. Larger quantities of this salt should be kept separate and it should not be mixed with the white salt, inasmuch as 1 ton of blue salt contains enough coloring matter to color intensely 20 tons of white salt. Smaller amounts should be dissolved in hot water, and this solution should be added to the bath, or about 10 to 20 kg. of salt should be added in a solid form to every fresh bath.

PRECIOUS METALS.

The Moore and Butters Filters.—In the *Mining and Scientific Press* for April 20, 1907, the arguments pro and con in regard to the Moore and Butters types of filters which have been mentioned repeatedly in the Digest are considered, and Mr. E. H. Nutter, assistant general manager of the Liberty Bell Mill at Telluride, Col. gives a brief résumé of the particular problems of these systems of working. Mr. Nutter thinks that the contention that the sum of advantages lies with the Butters-Cassel process is based on insufficient grounds and is incorrect, and that for small plants there is little to choose between the two processes. For plants of medium size with a treatment capacity of from 100 to 200 tons per day, where a good hillside site is available, which would make a gravity discharge for the Butters filter-boxes possible, the operating expenses of the two processes should be about the same, the

first cost being in favor of the Moore plant. Where, however, large tonnages are to be treated or where such a side-hill site cannot be had, the advantages of the Moore process, which consist in its lower power requirements, its greater compactness, its lower first cost and the higher time efficiency of the filtering units become of increasing importance. In Mr. Nutter's opinion, they outweigh whatever difference in repairs there may be in favor of the stationary filter. He thinks that in light of the experience so far obtained with the Moore process, there is no question but that rational design which takes account of all possible contingencies whose quantitative effects have been proved important will eliminate, practically, the faults that have so far developed. Comparing the Moore and Butters processes the operating labor is the same for both systems. The power requirements are less for the Moore process, and the technical efficiencies are about equal. The first cost of the Moore plant is less, and therefore the amortization and interest charges are also less. The royalty charges should be the same. Mr. Nutter thinks that, undoubtedly, the Butters process has so far made the best showing for filter repair expenses, but it seems probable that the new filters at the Liberty Bell will compare favorably with the Butters filters.

Lead.

Silver-Lead Smelting.—The views on silver-lead smelting practice of the late T. S. Austin, the well-known metallurgist, contained in letters to his brother, Prof. L. S. Austin, are published by the latter in *Mining and Scientific Press*. In regard to furnace running and conditions in the issue of March 16, Mr. Austin remarks that the metallurgist's skill and judgment come in "the running on the ragged edge," in order to get fast running of the furnaces and avoid too large loss of lead in the slag. The three furnace conditions are the following: (1) Ideal working. The slag assay gives medium results for lead, say, 1 to 1.2 per cent, the slag is fluid and hot, the speed of the furnace high, the smoke or fume escaping at the throat light in volume, color gray or dark, base bullion output good. (2) Under reduction. The slag is higher in lead, say, 1.2 up to 2 or even 3 per cent or more, the slag fluid but cold and red, looking heavy, the speed very high, the smoke thick and much in volume, with a grayish-white color, the base bullion output bad. To correct this condition there is needed extra fuel, scrap iron or some other reducing agent, and even a moderate lowering of blast. (3) Over reduction. The slag is low in lead, say, only a few tenths of 1 per cent, the speed much reduced and the furnace tightening, the slag slow-running but hot, the furnace top hot with white smoke when the fire mounts too near the surface, and very little at all when it is quenched back. The base bullion output is good but the crucible is liable to get sticky. This condition is to be corrected by cutting down the fuel. With high speed there should also be but little trouble in keeping the fore-hearth or settler open and in good condition, especially if one has much matte. Mr. Austin was of the opinion that fast running tends to increase the silver in the slag under certain circumstances, namely, when the silver and the lead are not allied in the minerals that compose the smelting mixture, that is, if the silver is in a silicious ore on the one side and the lead in a low-grade carbonate on the other side. In this case fast running will induce high silver slag, because the lead and silver will not have time to come into intimate contact and mixture. If the silver, however, is in a mineral together with lead, as an argentiferous galena, or with lead and copper as gray copper ore (tetrahedrite), or even as a sulphide with other base sulphides, it will be taken up by the lead much more rapidly and faster running will be permissible. One could readily conceive of a condition of affairs when almost any speed, within reason, would not seriously affect silver loss in the slag; thus the lead ores might be largely good grade argentiferous galena and carbonate mixtures, the silver ores medium or even high-grade quartz ores carrying the silver associated with lead, copper and iron sulphides. Considerable quantities of roast product, fused or sintered, might also be attainable, and roasted matte, containing copper, be largely used. In regard to the amount of blast, Mr. Austin holds that generally 15 ounces will give all that can be desired on an average coarse ore; speed can be gotten at that pressure by cutting down rather than by raising blast. The furnace should be driven all one can up to the point of hot top, avoiding always that objectionable feature.

American Museum of Security.

In our February issue, page 37, we discussed the exhibition of safety devices and in general of objects relating to industrial safety and industrial hygiene, held at that time at the Museum of Natural History in New York. This was the first exhibition of its kind and was held under the auspices of the American Institute of Social Service.

This first exhibition was such a success that the establishment of a permanent Museum of Security is now being taken into consideration. With the purpose of arranging the preliminary plan a conference was held on March 22, at which numerous editors and publicists of New York City were present. It was stated that even in New York City alone, taking the statistics for certain years, an average of from nine to thirteen persons met with violent deaths each day. Most of the accidents to which these deaths can be attributed are preventable by the use of proper safety devices.

The plan is to establish the permanent museum of approved safety devices at New York City, to which the public will have free access at all times. It is estimated that about $25,000 will be needed as the initial fund. About $1,500 has already been raised for this purpose, $1,000 of which has been pledged by the Non-Explosive Safety Naphtha Container Co., of New York City. The *Scientific American* has pledged the fund required for the annual award of a gold medal for the best safety device. An advisory committee was appointed, consisting of the editors of the leading technical and trade journals.

A meeting of this advisory committee was held on April 11, at which Mr. Charles Kirchhoff, of *Iron Age*, was elected chairman and Mr. T. C. Martin, of *Electrical World*, vice-chairman. A letter was read from Mr. Francis H. Richards offering a gold medal, to be awarded at the next exhibition, for the best invention shown relating to automobiles and motor boats. It was also announced that Dr. L. L. Seaman had offered an annual prize of $100 for the best essay on the subject of safeguarding life, the essay to be a study of existing conditions and methods for their improvements. Various committees were appointed to further the program, as outlined above, and it is hoped that the American Museum of Security will become a reality before the end of this year.

Rev. Dr. Josiah Strong and Dr. W. H. Tolman are the enthusiastic leaders of this movement.

A Modern Electrically-Operated Copper Converter.

By G. B. Shipley.

One of the most interesting and modern converter plants is now being erected by the Orford Copper Co. at Constable Hook, N. J., under the supervision of Mr. E. Franki, chief engineer. All of the machinery installed there has been designed to meet the most exacting conditions.

The converter equipment of the Orford Copper Co's new plant consists of three electrically-operated stands and nine shells 84 inches diameter by 126 inches long.

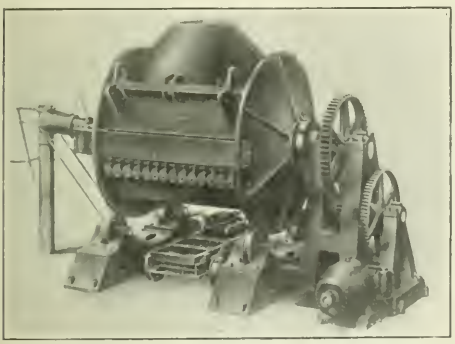
Shells.—Referring to the accompanying illustration it will be noticed that the shell has a peculiar shape at the top half,

which is not found in other converters. The bottom half is 84 inches diameter, and from the center up to the joint both sides of the shell are formed in a tangent to a width at the top of about 6 feet 8 inches. The object of this is to do away with the unnecessary curvature above the center line and permit of a more secure lining being formed therein.

The parting joint between the bottom half and top half is considerably higher than in other designs, the idea being to keep this just as high as possible and away from the extreme action of the molten copper; for it is a fact that in practically all of the barrel converters, with the exception of those at the Washoe plant, this joint is only carried a small distance above the center line, and since at this joint there is no chance to ram the lining, it is only possible to form the joint with an adobe mixture. The result is that under these conditions the joint is eaten away very rapidly by the molten matte. In our new type of converter, however, that particular and vital defect has been overcome by raising the joint between the bottom and top shell.

The bottom section of the shell is made of flange steel plate, and at both ends it is rigidly secured to a solid cast steel head provided with a riding ring completely encircling the head.

Each head is spherical in shape and re-enforced with six heavy ribs to reduce expansion and contraction due to the intense heat. In a great many converters, which have been designed without the ribs, much trouble has been caused and a great deal of expense incurred in fitting new shells into stands which had the air connections bolted to the heads.



ELECTRICALLY OPERATED COPPER CONVERTER.

For lifting the shells, there is riveted at the joint a solid cast steel re-enforcing plate on the lower half, which has cast integral with it one heavy lug on each end of each plate, making four lifting lugs in all. These re-enforcing plates or angles are also arranged for bolting on the top half by three extra heavy bolts on each side.

The top half is slightly different from what is shown by the cut, inasmuch as there is furnished an independent pouring nose which is bolted to the cast steel top and can be renewed from time to time as it is eaten away.

In some cases a great many operators object to the short cast iron pouring nose, for the reason that accretions form very rapidly on the flanges, and they prefer to have a plain nose which can be re-enforced with steel plate when eaten away. The shape of this top, as well as the bottom, in this particular converter is practically the same as the converters in use at Anaconda, and is a peculiar shape which has proven to give a longer life to the lining.

The reader will note, by referring to the cut, that the wind-box is made rectangular in shape and consists of a plain casting that lies close to the shell and underneath the riding ring, thus permitting the shells to make a complete revolution and thereby do away with the stop which it has been customary to place on a great many riding rings in order to protect the wind-box and prevent the shell from turning too far.

With the old stop arrangement it was necessary to be very careful in turning, otherwise an operator would throw the shells off the stands and thus cause a serious accident.

Another feature of the self-contained wind-box is that it does away with the long flange and cover that has always been used where the air valves of tuyeres were fitted on the inside of the wind-box.

It is well known that there is always a great loss of air through the joint in the long cover ordinarily used, because the expansion and contraction and the hard service to which converters are subjected in a very short time ruins the joint.

Individual Tuyeres.—On this particular converter there are fitted fourteen Repath individual tuyeres, and each tuyere is fitted with a Dyblie ball valve.

Each tuyere is secured to the wind-box by swing bolts, and the discharge end, which is at right angles to the inlet, projects several inches inside the shell and through a cast steel stuffing box which is secured to the shell. This stuffing box is bored out to suit the projection on the tuyere and arranged for holding asbestos packing, while the projection is sufficient so that a lining of brick can be fitted securely around the end and thus prevent air leaks.

Each tuyere is arranged so that the ball valve and its seat are self conained, and the valve can be taken out and replaced by another very rapidly. The pipe distance piece is also independent and very accessible. It will, therefore, be seen that with this individual arrangement of tuyeres it is only necessary to disconnect two swing bolts and put out the tuyeres. It is not necessary, when replacing a single defective pipe-distance piece, to disconnect a long and heavy cover and have the great difficulty of trying to make a joint on a long and warped casting.

The general opinion of many will probably be that accretions will form between the wind-box, tuyeres and shell, and to such an extent that it will not be possible to get at the swing bolts that fasten the tuyeres to wind box; but such is not the case, because to obviate this there is an angle on top of the wind-box running the full length and riveted to shell.

It has been demonstrated that the ball valve is more satisfactory than the roller valve, because the spherical shape of the ball adjusts itself to the valve seat and there is no chance for grooves forming, due to the hard usage and constant pounding of the tuyere punching bar.

Air Connection.—On the air end of each shell the cast steel head is arranged to receive the end of the wind-box, which is fitted with a ball-joint concave flange, and receives the stationary air nipple of the patented blast connection.

This joint is especially adapted to converters and air joints where it is not possible to bring flanges in line, due to the difference in centers of shells, which are bound to become distorted and lose part of their shape after hard usage. This connection consists of a cast iron T, having the horizontal cylinder fitted with a ball joint and piston. When the shell is moved into position the lever is pushed forward, and this moves the nipple into the concave flange on the head. The air is then turned on and the pressure upon the piston holds the joint rigidly in place.

This joint is far superior to the old method of matching flanges and has proved to be a great labor-saving device around converting plants.

Electrically-Operated Stands.—For turning the shell each stand built for the Orford Copper Co. is provided with a 30-hp Allis-Chalmers direct current, variable speed, multipolar, enclosed type series wound motor for 110 volts and 600 revolutions per minute, which is geared up to the main drive shaft so that the maximum speed of shell is reduced to 1½ revolutions per minute. (In plants where alternating current is available, induction motors are, of course, used to turn the

converters, and for this service they offer a number of special advantages.)

For regulating the turning speed of the converter shells there is a suitable controller, arranged with a liberal number of speeds in each direction.

The motor shaft is connected to the worm shaft by a coupling, which also acts as a brake wheel for the solenoid brake, and on this extension is keyed a single-thread steel Hindley worm that runs in an oil bath and meshes with a solid worm wheel, thus making the first reduction. On the worm wheel shaft is secured a cast steel pinion which in turn transmits its energy to a cast steel gear, both having shrouded teeth and designed for taking care of severe shocks.

The gear is keyed to a hollow steel shaft, which has fitted to the driving end a universal coupling, arranged so that the shells will lie true on the rollers and at the same time the drive will adjust itself to suit the alignment, and thus avoid any undue strains on the drive shaft.

On the head of the shell is a groove, which matches a tongue on the universal drive, and when placing the shell in position on the stand the motor is turned around until the tongue is vertical when the shell is placed, and there is clearance enough on each side of the tongue for keys, which are tapped into place by a light hammer, thus holding the shell rigid to the universal connection.

In some converters this groove on the shell has only sufficient clearance to allow the shell to drop over the tongue and no provision is made for using the keys, in which case there is a chance for a back lash, due to the clearance and the fact that the motor will have a chance to accelerate before it picks up the shell, and the result is a severe shock which is very detrimental to the train of gears.

Motors for turning converters have very severe work to perform, and in this case the maximum starting torque of motor is several times greater than the full-load torque. All possible chance of the shells turning when the current is turned off is prevented by an automatic braking device.

The complete "A" frame for supporting the motor and carrying the gears consists of a massive box frame casting with all bearings liberally proportioned and lined with the very best babbitt.

Housing.—There is a sheet steel housing for each frame, which covers all the driving gear and motor complete, as shown in dotted lines on the cut, to prevent dirt from getting into the operating parts.

Pouring Spoon.—A very important detail in connection with the pouring operation of converting is to obviate spatter or spill of the copper upon the floor, and to prevent this there is a Bennetts pouring spoon, hung on a steel arm on one side of the roller stand, with the arm so arranged that the spoon can be adjusted to suit the pour of copper from the shell and the position of the moulds which rest on the truck directly underneath.

General.—Another important detail which is not shown in the cut is a mould car mover, which is attached to a slide on the inside of the roller stand next to frame, and this mover is operated by an air cylinder, which in turn transmits its power through a piston rod to a guide which has an arm that can be dropped into place on a mould car and thus push the car along into the proper position to suit the moulds.

The three stands are operated from a pulpit which is located on the opposite end of building and off to one side, and this is where the controller, air blast and mould car operating levers for all three stands are placed, so that they may be manipulated by one operator.

It is safe to say that the following data is close enough for practical estimating purposes:

	Tons.
Weight of shell	13
Weight of lining	28
Total	41

Cubic feet of concrete in foundation 960.

Capacity of charge 40 per cent matte.

First charge (new lining)	5¼
Average charge (new lining)	6¼
Maximum charge	9 to 10

Blowing time—

	Minutes.
First skimming for slag	45
Second skimming for slag	60
To blister copper	135
Total	240 = 4 hours.

Air blast pressure 10 to 12 pounds.

Therefore, assuming six charges per stand per 24 hours and 26 working days per month, the capacity of each 84-inch x 126-inch converter will be about 780,000 pounds of copper per month. Of course, this will all depend upon the matte and the conditions under which the converter is operating. In some cases this capacity could be increased 30 per cent where they are converting under ideal conditions, whereas in others the above capacity would be high for badly arranged plants.

Mr. C. H. Repath, engineer of the Anaconda Copper Mining Co.; Mr. F. E. Marcy, of Salt Lake; Mr. J. A. Dyblie and Mr. B. H. Bennetts all deserve special mention for the many special features which are incorporated in this machine.

Long-Scale Switchboard Instruments.

Recognizing the need there is for switchboard instruments well suited for use with generators of large capacity and where readings must be made at a considerable distance from the switchboard the American Instrument Co., of Newark, N. J., has recently placed on the market a new long-scale instrument which is shown in the accompanying illustrations.

These instruments are provided with scales approximately 14 inches long, or twice the length of the usual large-size round-pattern instrument. Owing to this there is ample room

FIG. 1.—LONG-SCALE SWITCHBOARD VOLTMETER.

for large divisions and large figures, which, together with the unique method of marking the scales (clearly shown in Fig. 1) make them extremely clear and legible. For this reason they are particularly well adapted for use with generators of capacities running up to several thousand amperes and also where it is essential that accurate readings be made from a considerable distance.

Perhaps the most unique feature of these instruments is the

method of mounting them on the switchboard. When an instrument with a long-scale as described above is mounted entirely on the front of the board it projects a considerable distance, and is more or less in the way, while if the same instrument is mounted flush it requires cutting a large irregular shaped hole, which weakens the panel very materially. The way in which this new instrument is constructed entirely obviates both of these difficulties. It projects less than 2 inches from the front of the board and at the same time only requires a circular hole 6⅝ inches in diameter to be cut in it. Thus they are easy to mount, the panel is not unduly weakened and they offer all the advantages of the flush-type instruments. Very satisfactory illumination may be obtained by means of a lamp and bracket mounted over the instrument.

Fig. 2 shows the construction of the case which allows for this unusual method of mounting. The instrument proper is mounted on a circular box as shown, and this projects through the board while the shallow portion of the case contains the scale and lies flat against the front of the switchboard. Altogether, the finished appearance of these instruments is particularly attractive and adds materially to the distinctive character of any switchboard.

FIG. 2.—SIDE VIEW OF LONG-SCALE SWITCHBOARD VOLTMETER.

The internal construction of these new type-3 instruments conforms strictly to the high grade of excellence which the American Instrument Co. has already established in its round pattern and portable instruments. The magnets are of the very best magnet steel, aged and magnetized according to the latest and most approved methods. The mechanical construction of the moving coil, its mounting, etc., are extremely simple and rugged, so that they are well adapted for the hard service which is bound to come to any switchboard instrument.

Ammeters of this new type are arranged to operate in connection with the regular interchangeable switchboard shunts which are used with round-pattern switchboard instruments. These shunts are adjusted to give a uniform drop of exactly 50 milli-volts on full load. Also the instrument, together with its leads, is adjusted to have an exact resistance of 1 ohm and to give full deflection on 50 milli-volts. Thus it is clear that any shunt of any capacity can be used with any instrument and any pair of leads, and correct results will be obtained. This feature is of greatest advantage, as it allows the use of any number of shunts of any capacity on one indicating instrument, the only requirement being that a suitable two-pole switch of negligible resistance be inserted in the leads between the instrument and shunts. Also should an instrument be disabled through accident it can be returned to the factory for repairs and properly adjusted without disturbing the shunt at all; and while it is out of commission another "American" ammeter, whether of the same or different type, may be used and correct readings obtained, when the proper multiplier is used to make the scale values agree with the shunt capacity.

These long-scale voltmeters in common with all "American" voltmeters whether of switchboard or portable types are adjusted to have a uniform resistance of exactly 100 ohms per volt, so that a 150-volt instrument has just 15,000 ohms total resistance and a 300-volt instrument exactly 30,000 ohms resistance and so on. This uniformity makes it possible to use multipliers interchangeably should they be required, and also adapts the instrument for measuring insulation resistance and grounds most satisfactorily.

Where generators of large capacity are used there will naturally be large currents flowing in the bus-bars, which will set up magnetic influences which effect the readings of the ordinary instrument. The American Instrument Co's long-scale instruments as well as its other switchboard round-pattern instruments are, however, provided with soft drawn sheet steel cases, which provide a most efficient magnetic shield for the internal parts, so that powerful external fields do not influence the indications. As these cases are drawn into shape the material must be of uniform softness throughout. In consequence of this there is practically no danger of the cases becoming permanently magnetized as they do when cast iron is used. In addition to the shielding quality of these cases they are so designed that where parts come together there is ample bearing service, which effectively prevents the entrance of dust.

Mr. James G. Biddle, 1114 Chestnut Street, Philadelphia, is general sales agent for the American Instrument Co.

A Non-Stop Run.

Electrical generators have become such a standard product that attention is seldom called to that thoroughness of design and construction which results in such a record of reliability as that shown in the following statement concerning a 150-kw., three-phase, belt-driven alternator built by the General Electric Co. This generator ran more than four years, 24 hours a day, with a single stop of 15 minutes, due to a defective pulley. The details of this performance are given by Mr. Rhodes,

ALTERNATOR HAVING MADE A NON-STOP RUN OF MORE THAN FOUR YEARS.

assistant manager of the United States Smelting Co., West Jordan, Utah, as follows:

"The generator was received about June 1, 1902. Put in service Oct. 15 for 11 hours per day until Nov. 9, when 24 hours per day service was required. Jan. 25, 1904, shortly after noon, the paper pulley on exciter went to pieces. A cast iron pulley being on hand a shut-down of 15 minutes was recorded. From June 13 to 18, 1904, the switchboard was moved, and all feeder circuits were connected directly on the machine without switches or fuses by means of jumpers without a single mishap to cause a shut-down. Last Fall one of the screws worked out of one of the split oil rings on pulley end. Not being able to shut down we ran along with the remaining one till March 28, 1907, when the machine was shut down for three days, thoroughly cleaned out, new oil put in bearings, collector rings turned true, the broken oil ring fixed, and service commenced as usual, vacuoline oil being used during this run.

The alternator is belt-driven, and an engine located at either side with belt attached in case of emergency. Bearing in mind that this machine carries a continuous overload of 25 to 60 per cent its record is truly wonderful."

Notes.

Electric Power from Blast Furnace Gases.—From a European exchange we note that La Société des Forges d'Eich is installing at Dommeldingden, in Luxemburg, a central station which will be worked by blast furnace gas. A contract has been made for a term of fifteen years with the town of Luxemburg for the supply, for lighting and other industrial purposes, of all the energy over and above that necessary for the society's own needs. The price is fixed at 1.4 cents per kilowatt-hour for the first 2,000,000 kw-hours and 1.2 cents per kilowatt-hour after. The cost of generation is estimated to be 0.5 cent.

Zinc Dust in Cement.—It has been known for some time that a cement made out of certain oils and zinc dust possesses the useful property of becoming exceedingly firm and adhering closely to iron, steel and other metals when heated to a temperature of 150 C., or even less, if treated for a sufficient length of time. The theory of the nature of zinc dust which Mr. Alfred Sang has given in his article on Sherardizing in our last issue, explains this hardening by the release of the zinc from its peculiar condition, to form a solid without the formality of passing through the liquid stage. In the body of the cement it is protected from oxidation and the zinc becomes mechanically continuous. It is an excellent composition for calking cracks and crevices in metallic objects, for packing joints and for smoothing off the surface of castings.

Copper Refining in Australia.—The Electrolytic Refining & Smelting Co. of Australia, Ltd., has been formed and registered in New South Wales, with a capital of £150,000, for the purpose of treating and smelting ores and mattes containing copper, gold and silver and of refining electrolytically blister copper produced by the company's own smelting works and other smelting works in Australia. The office of the Electrolytic Refining & Smelting Co. will be at 118 Pitt Street, Sydney. One of the directors is Capt. G. A. Richard, general manager of the Mount Morgan Gold Mining Company, who was recently in this country, accompanied by their chemist and assayer, Mr. B. du Faur, and attended the meeting of the American Electrochemical Society in Philadelphia. The Mount Morgan Gold Mining Co. was formerly one of the largest gold producers of the world and is now a very large copper producer. The intention of the Electrolytic Refining & Smelting Co. of Australia, Ltd., is to erect a large plant in some suitable central position and thereby to start practically a new industry for Australia. The Mount Morgan Copper Company of Queensland, in consequence will relinquish the intention of erecting its own electrolytic refinery at Mount Morgan in favor of joining the new company. Mr. Benjamin Magnus, formerly with the Anaconda Copper Refinery, the Buffalo Smelting Works and more recently with the Mountain Copper Company, will be the general manager of the new refinery.

Thermit versus Weldite.—A suit was tried recently in England between Thermit, Ltd. (the English company affiliated with the Goldschmidt Thermit Co. of this country) as plaintiffs and Weldite, Ltd., as defendants. Judgment has recently been rendered by Justice Warrington. It appears that "weldite" differs from thermit in so far as mixture of aluminium and silicon is employed instead of the pure aluminium in thermit, and was used, like thermit, for rail welding. Concerning this the judge speaks as follows: "The defendants have beyond question carried out the reduction of oxide of iron in the manner described in the specification, with one exception, namely, that they have replaced a small portion of the aluminium by silicon, another metal capable of reducing iron." The defendants denied infringement and attacked the validity of the patents owned by Thermit, Ltd., on a number of grounds. Concerning the infringement the judge continues immediately after the passage quoted above as follows: "In my opinion the true result of the evidence on this point is that this change is a mere colorable variation, that the reduction, notwithstanding the variation, continues to be substantially a reduction by aluminium such as is described." The judge found, as the result of the whole case, that the complainants are entitled to an injunction as to all the patents. These are thereby fully sustained.

Ferro-Alloys.—In our February issue we noted the formation of the Electro Metallurgical Co. In the meanwhile the works and business of the Willson Aluminum Co. have been acquired by the Electro Metallurgical Co. The official announcement of the Willson Aluminum Co., signed by the president, Mr. J. T. Morehead, reads in part as follows: "We beg to announce that our works at Kanawha Falls, W. Va., have been sold and transferred to the Electro Metallurgical Co. The sale includes our business, good will and patents, so far as they relate to the manufacture and sales of ferro-alloys. Among the numerous patents acquired by the new company from ourselves and others, covering the manufacture of ferro-chromium, ferro-silicon and other ferro-alloys, are our fundamental patents, broadly covering the manufacture, use and sale includes our business, good will and patents, so far as product, and the processes applicable to its manufacture. The Electro Metallurgical Co. has ample capital, an experienced staff and adequate reserve electrical power, and is prepared to maintain the highest standard of quality and to make prompt shipment of its products." The Electro Metallurgical Co. intends to manufacture products of the highest grade, consisting for the present mainly of ferro-alloys low in carbon. The company has an office at 79 Wall Street, New York, but the general offices are located at 157 Michigan Avenue, Chicago, Ill. Mr. E. F. Price is general manager of the company.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

Calcium Carbid (*Continued*).*

No. 541,138, June 18,1895, Thomas L. Willson, of New York, N. Y.

Crystalline calcium carbid existing as masses of aggregated crystals, having a bluish or purplish iridescence. The described mode of production is that of Willson, 541,137.

Reissue 11,511 of original 541,137, Oct. 22, 1895, T. L. Willson, of New York, N. Y.

The description is corrected to state that the current is reversed fifty times a second instead of fifty times a minute.

No. 552,890, Jan. 14, 1896, W. C. Clarke, of New York, N. Y.

Employs a furnace, the circular wall of which is gradually built up of semicircular or other curved pieces of tile or firebrick, as reduction of the charge proceeds. In starting, a piece of sheet iron constituting the lower electrode may be placed on the ground and the lowermost layer of the wall placed thereon. The charge mixture, pulverized lime twenty parts and carbon twelve parts, is then introduced and smelted by the use of a depending carbon electrode. When the initial charge is reduced, another layer of the wall is added, the carbon electrode raised and a fresh charge thrown in. The reduction and building up proceeds until the height becomes inconvenient or the resistance too great. The lower end of the carbon electrode is kept near the upper edge of the furnace wall, permitting the hot gases to escape without coming in contact with this electrode, whereby its life is prolonged. The resulting column of carbid, which, during operation, constitutes the lower electrode, is separated from the wall by an unreduced layer. This falls away as the wall is removed and is used, while hot, for a subsequent charge. The carbid as it cools is grappled and removed.

NEW BOOKS.

Report on the Experiments Made at Sault Ste. Marie, Ontario, Under the Government Auspices, in the Smelting of Canadian Iron Ores by the Electrothermic Process. By Dr. Eugene Haanel. 150 pages. Illustrated. Ottawa, Ont., Can.: Department of the Interior, Mines Branch.

Theories of Chemistry. Lectures delivered at the University of California. By Svante Arrhenius. Edited by T. S. Price. 212 pages; illustrated. Bound in cloth. Price, $1.75. New York: Longmans, Green & Co.

Experimental and Theoretical Applications of Thermodynamics to Chemistry. By Walter Nernst. 133 pages. Illustrated by diagrams. Bound in cloth. Price, $1.25. New York: Charles Scribner's Sons.

Fire Assaying. A practical treatise on the fire assaying of gold, silver and lead, including description of the appliances used. By Evans W. Buskett, B. S. 105 pages; 70 illustrations and many tables. Bound in cloth. Price, $1.25 net. New York: D. Van Nostrand Co.

Foods and Their Adulterations. By Harvey W. Wiley (Department of Agriculture, Washington). The origin, manufacture and composition of food products, description of common adulterations, food standards and national food laws and regulations. A guide to the chemist in detecting impurities in food. Bound in cloth. 625 pages. Illustrated. Price, $4.00 net. Philadelphia, Pa.: P. Blakiston's Son & Co.

Denatured or Industrial Alcohol. A treatise on the history, manufacture, composition, uses and possibilities of industrial alcohol in the various countries permitting its use and the laws and regulations governing the same, including the United States. By Rufus Frost Herrick. 512 pages; 163 figures. Bound in cloth. Price, $4.00 net. New York: John Wiley & Sons.

Industrial Alcohol. Its manufacture and uses. By John K. Brachvogel, M. E. (A practical treatise on Dr. Max Maercker's Introduction to Distillation, as revised by Drs. Delbrück and Lange, comprising raw materials, malting, mashing and yeast preparation, fermentation, distillation, rectification and purification of alcohol, alcoholometry, the value and significance of a tax-free alcohol, methods of denaturing, its utilization for light, heat and power production, a statistical review, and the United States law). 500 pages; 105 engravings. Price, $4.00. New York: Munn & Co.

Journal of the Iron and Steel Institute. Extra volume for 1906. Edited by B. H. Brough. Bound in cloth. Price, $6.00. New York: Spon & Chamberlain.

The Analysis of Silicate and Carbonate Rocks. By W. Francis Hillebrand. 202 pages; illustrated with diagrams and tables. Price, 30 cents. Washington, D. C.: Office of the Superintendent of Documents.

The Value of Pure Water. By George C. Whipple. 84 pages. Bound in cloth. Price, $1.00 net. New York: John Wiley & Sons.

The Bacteriological Examination of Water Supplies. By William G. Savage. 297 pages; 13 illustrations and several tables. Bound in cloth. Price, $2.50 net. Philadelphia, Pa.: P. Blakiston's Son & Co.

How to Check Electricity Bills. Containing methods of charging for electricity with directions for reading and testing electric meters. By S. W. Borden. 54 pages, 31 illustrations. Bound in cloth. New York: McGraw Publishing Co.

Practical Illumination. By J. R. Cravath and Van Rensselaer Lansingh. 370 pages; 400 illustrations. Bound in cloth. Price $3.00 net. New York: McGraw Publishing Co.

Design and Construction of Hydroelectric Plants. Including a special treatment of the design of dams. By R. C. Beardsley. 520 pages; 480 illustrations. Bound in cloth. Price, $5.00 net. New York: McGraw Publishing Co.

BOOK REVIEWS.

Hydrometallurgy of Silver. By Orlokar Hofman. 8vo., pp. X + 345. 82 illustrations. Price, $4.00. New York: Hill Publishing Co., 1907.

A most timely work on an important branch of metallurgy, by one of the men best able to handle the subject. It is true, as pointed out in the preface, that great improvements have been made in chloridizing roasting, the preliminary to most wet extraction methods, and in the use of cyanide solutions on silver ores, and yet the literature of silver has not kept pace with these improvements.

In this work we find, in Part I., 154 pages upon chloridizing roasting, a fuller and more satisfactory treatment of this subject than is to be found anywhere else, but we must confess to some disappointment at the frequent absence of precise figures and the use of such expressions as "require much fuel," "if the heat is too high," "most of the lead." We do not know whether Howe's temperature measurements on the sulphating roasting of silver sulphide were ignored because unknown to the author or because he did not consider them reliable, but we certainly expected to find such precise data referred to in this work. Several important subjects, like the collection of flue dust, are dismissed too briefly.

Part II., containing 190 pages, discusses the extraction of the silver from roasted ore, or from raw ore if suitable. Treatment with hyposulphite solution claims over half this space, and is very practically and clearly written. There is a brief obituary of four pages upon the Russell and the Kiss processes, it being baldly stated that neither of them are a success. For a discussion of these the metallurgist will still have to refer to Statefeldt's "Hyposulphite Lixiviation of Silver Ores."

We are afraid that the author's experience with the cyaniding of silver ores is much less extensive than with the hyposulphite method, for the forty-page chapter on it is practically entirely a compilation; and we cannot agree, in view of the metallurgical revolution which cyaniding has accomplished in Guanajuato, for example, that this process is "more or less in its experimental stage" with regard to silver ores. It is more than probable that the hyposulphite process itself is eventually doomed to practical extinction by the improvements which will be made in cyaniding silver ores. We wish that this process had been given a masterful exposition, for such was needed and should have been found in this volume.

Altogether, our rapidly expanding metallurgical literature in English has gained new honors by this timely work.

* * *

Fire Assaying. By Evans W. Buskett, B. S., chemist of the Ozark Smelting & Mining Co. 12mo., 105 pages. Price, $1.25 net. New York: D. Van Nostrand & Co.

An elementary presentation of the assaying of gold, silver and lead ores, which first appeared serially in *Mines and Minerals*, and is here rewritten, revised and augmented. The eight chapters deal respectively with sampling, reagents and fluxes, assay of acid ores, assay of basic ores, lead assay, bullion assay, methods of handling work and laboratory tests, etc.

The chapter on sampling is well illustrated and is very practical, but some statements are inaccurate, such as the definition of a "salted" sample. The information on reagents and fluxes is condensed, but to the point so far as it goes. The information as to acid and basic ores is hardly sufficient to give the beginner the right idea as to their essential characteristics, the details are too vague and precise figures lacking. The chapter on lead assaying is totally inadequate to teach the subject properly to anyone. The bullion assay is fairly well described. The chapter on methods of handling work contains some very useful directions for the beginner. The laboratory tests are well written.

Altogether, the beginner would learn easily from this book

JUST PUBLISHED

12mo, Cloth 498 Pages Price, $2.50 Net

Van Nostrand's
CHEMICAL ANNUAL

A Hand-book of Useful Data
for Analytical, Manufacturing and Investigating Chemists, and Chemical Students

Based on Biedermanns' "Chemiker Kalender"

EDITED BY

Prof. J. C. OLSEN, A.M., Ph. D.
Polytechnic Institute, Brooklyn
Formerly Fellow Johns-Hopkins University
Author of "Quantitative Chemical Analysis, by Gravimetric, Electrolytic, Volumetric and Gasometric Methods."

With the Co-operation of Eminent Chemists

FIRST YEAR OF ISSUE, 1907

The absence of a comprehensive reference book of numerical data of the Science, has induced the publishers to undertake the publication of this Annual, which it is their intention to issue, with new data added, annually.

8vo, Cloth 367 Pages Price, $3.00 net

SOLUBILITIES
OF
Inorganic and Organic Substances

A Hand-book of the most
Reliable Quantitative Solubility Determinations

COMPILED BY

ATHERTON SEIDELL, Ph.D. (J.H.U.)
Bureau of Chemistry, U. S. Department of Agriculture

The principal features which have been emphasized in the preparation of this volume are as follows:

Completeness of Data
Uniformity of Expressing Results
Selection of Most Reliable Determinations
Arrangement of Material

RECENTLY PUBLISHED

8vo, Cloth, Illustrated, 298 pages Price, $3.00 net

EXPERIMENTAL
Electrochemistry
Theoretically and Experimentally Treated

BY

N. MONROE HOPKINS, M.Sc., Ph.D.,
Assistant Professor of Chemistry in the George Washington University, Washington, D. C.

Profusely Illustrated with 130 New Drawings, Diagrams and Photographs, accompanied by a Bibliography.

D. VAN NOSTRAND COMPANY
Publishers and Booksellers
23 Murray and 27 Warren Sts., New York

much about assaying, and would lack very much of being "an assayer" when he had mastered all its contents.

* * *

Electric and Magnetic Measurements and Measuring Instruments. By Frank W. Roller, M. E., member A. I. E. E., A. S. N. E., A. E. S., etc. $3.50 net. New York: McGraw Publishing Co.

Mr. Roller's work should prove a useful reference book to those who have to do with electrical and magnetic measurements. It is fully illustrated and a useful appendix gives the names of the makers of the various instruments described in the text.

The book is divided into three parts, the first dealing with measurements of resistance, current, potential, capacity, etc.; the second part describing various recording instruments, and the third part covers magnetic measurements.

In all cases a brief description of the general construction and principle of the various instruments is given, which, as the author points out, will enable the engineer to decide which are best suited for his general requirements.

The diagrams in the book are very clear, but some of the photographic reproductions of instruments are not all that could be desired.

* * *

A Textbook of Elementary Analytical Chemistry. By John H. Long, M. S., ScD., professor of Chemistry and director of the Chemical Laboratories in the Northwestern University Medical School. Illustrated. Price, $1.25 net. Philadelphia: P. Blakiston's Son & Co.

This is the third edition of this textbook and has been revised and enlarged.

The author in his preface to this edition says that experience has convinced him of the practical value of the plan of the work as originally laid out, viz.: The following up of a course in qualitative analysis by instruction in volumetric work. He thus finds that "the knowledge of quantitative chemistry which may be imparted in this way in a limited time is certainly greater than can be given by gravimetric analysis in the same period."

The new edition contains important additions. Among these is a chapter discussing in general reactions in solutions, and there have also been introduced a large number of simplifications in qualitative work.

The book is evidently designed for the use of the general student, medical, pharmaceutical, etc., and does not profess to be a textbook for the regular analytical chemist.

* * *

Report on the Experiments Made at Sault Ste. Marie, Ontario, Canada, under Government auspices, in the smelting of Canadian iron ores by the electrothermic process. By Eugene Haanel, Ph. D. 150 pages; fully illustrated. Ottawa, Canada: Department of the Interior, Mines Branch.

This is the full official report on the now celebrated experiments made last year with the Héroult furnace at the Soo, under the supervision of Dr. Eugene Haanel, superintendent of mines and the author of this report. The preliminary report has been discussed and abstracted at length on pages 124, 265 and 332 of our Vol. IV. The present full report differs from the preliminary report only in giving a few more details and a complete record of all the runs which were made.

It will be remembered that after the tests had been concluded the experimental furnace was taken over by the Lake Superior Power Co. for the purpose of producing ferro-nickel pig on a commercial scale. The following statements of Mr. E. A. Sjöstedt, chief metallurgist of the Lake Superior Power Co., on the progress of this work (page 94 of the present report) are interesting. During the four full months from April to July, inclusive, 1906, the furnace was in continuous operation, with the exception of such unavoidable interruptions as were

caused at the power plant and for the change of electrodes. The total product of these four months was 154 short tons, the total working time 114.8 days of 24 hours, the average product per working day being 1.3415 short tons.

The mean voltage of the electric furnace was 38, the mean current was 4,800 amps., the power factor 0.919, the mean electric power approximately 225 hp. Hence the output of ferro-nickel pig per 1,000 electric horsepower-days was 5.96 short tons.

During this period the following average amounts of raw material were consumed for the production of one short ton of ferro-nickel pig: Two tons of roasted pyrrhotite (about 2 per cent sulphur content), 1,500 pounds limestone, 1 200 pounds charcoal and 40 pounds of electrodes. The ferro-nickel pig product had an average composition of about 2.75 per cent Si, 0.01 per cent S, 0.03 per cent P, 4 per cent Ni, and 0.8 per cent Cu.

The report proper fills 100 pages of the volume. The balance is filled by an appendix. Valuable and interesting descriptions are first given of eight new furnaces invented by three Swedish engineers, Messrs. A. Grönwall, A. Lindblad and O. Stalhane. The first three furnaces described are induction furnaces, and the special features of their design are means for the reduction of the phase displacement by diminishing the primary magnetic leakage. The other five furnaces of the same inventors are intended for the reduction of ores, and include an induction furnace, a resistance furnace with electrodes and a rotating furnace. Brief notes are also given on the results obtained with the Héroult furnace in Germany, and the proposed new construction of an electric smelting furnace by Mr. R. Turnbull, the Canadian representative of Dr. Héroult, with brief notes on commercial developments with respect to the Héroult furnace in Canada and the United States. As far as new information is contained in this appendix it will be covered in detail in our next issue.

Like the report of the Canadian Commission of 1904 the present volume is handsome, well printed and profusely illustrated, and those who have contributed to this important work, especially Dr. Eugene Haanal, deserve the sincere thanks of the profession. We cannot do better but repeat what the London *Electrician* said editorially concerning the report of Dr. Haanel's commission of 1904: "It stands a monument of legitimate government activity directed with intelligence and achieving its goal."

* * *

Elektrometallurgie des Eisens. By Prof. Dr. Bernhard Neumann. 176 pages; 89 illustrations. Price, in paper cover, marks 7.00 (retail price in New York, $2.35). Halle a. S.: Wilhelm Knapp (volume 26 of the German monographs on applied electrochemistry).

Very much has been published in recent years on the electrometallurgy of iron and steel, but, with the exception of the two handsome volumes of the Canadian Commission, the information is scattered throughout the pages of various engineering journals. The present book will undoubtedly be welcome to many interested in this timely subject, as it is the first classified summary of the great progress which has been made. The book is chiefly descriptive and contains hardly anything that has not been published in the columns of Electrochemical and Metallurgical Industry, but this does not diminish the value of the volume as a ready reference book. The descriptions are concise and clear and fully illustrated.

After some historical notes, recent processes and apparatus are described. They are sub-divided into two classes, those which use carbon electrodes (Stassano, Conley Galbraith and Stewart, Grange, Peterson, Gerard, Harmet, Gin, Neuberger-Minet, Héroult, Keller) and those which do not use carbon electrodes (Kjellin, Hiorth, Schneider, Colby, Fanchon, Gin, Girod). The next four chapters give data on results of operation, quality of products, power consumption, thermal efficiency

JUST READY

"FOODS AND THEIR ADULTERATIONS"

The Origin, Manufacture and Composition of Food Products, Description of Common Adulterations, Food Standards, and National Food Laws and Regulations

By HARVEY W. WILEY, M. D.

Chief Chemist, U. S. Department of Agriculture, Washington, D. C.

A guide to the chemist in detecting impurities in food.

11 Colored Plates and 86 other Illustrations

Octavo: 625 pages Cloth, $4.00 net

Synopsis of Contents:—Introduction.—Meats.—Poultry and Game Birds.—Fish Foods.—Milk and Milk Products.—Cereal Foods.—Invalid and Infant Foods.—Vegetables, Fruits, Spices, Nuts, Etc.—Sugar and Honey.—Food Standards, Rules and Regulations for Enforcing the Food and Drugs Act.—Regulations Governing Meat Inspection.—Index.

Orders may be sent to any bookseller; or upon receipt of price we will forward to any address, postage or express charges prepaid.

P. Blakiston's Son & Co.

SCIENTIFIC PUBLISHERS

1012 Walnut St., Philadelphia

Handbook of Mathematics

FOR ENGINEERS AND ENGINEERING STUDENTS

By J. CLAUDEL

Translated and Edited from the Seventh French Edition by OTIS ALLEN KENYON

A complete book on Mathematics
It covers very thoroughly
Every branch from Arithmetic to Calculus

TABLE OF CONTENTS

Part I.—Arithmetic. I.—Fundamental Operations on Whole Numbers. II.—Properties of Whole Divisors. III.—Fractions and Decimal Numbers. IV. Powers and Roots. V.—Ratios, Proportions, Progressions. VI.—Diverse Rules. VII.—Logarithms. Part II.—Algebra. I.—Of the Four Fundamental Algebraic Operations. II.—Equations of the First Degree. III.—Powers and Roots of the Algebraic Quantities. IV.—Equations of the Second Degree. Part III.—Geometry. Plane Geometry. Solid Geometry. Problems in Geometry. Part IV.—Trigonometry.—Plane. Spherical Trigonometry. Part V.—Analytical Geometry Part VI—Calculus. I.—Differential Calculus. II.—Integral Calculus. III.—Applications of Integral Calculus.

Cloth, 708 Pages. 422 Illustrations. Price, $3.50 Net.

Sent anywhere postpaid for the price

Send Us Your Inquiries Write For Our Catalogs

McGraw Publishing Company

PUBLISHERS, IMPORTERS AND BOOKSELLERS

114 Liberty Street, New York

ROBINE-LENGLEN-LE CLERC — *The Cyanide Industry Theoretically and Practically Considered.* 8vo, xi + 408 pages. 1906. Cloth, 4 pages.

WILSON — *Cyanide Processes.* 12mo, vi + 206, 12 figures. (1902). Cloth, $1.50.

MILLER — *The Cyanide Process.* 12mo, viii + 95 pages, 28 figures. (1906). Cloth, $1.00.

MILLER — *A Manual of Assaying.* 12mo, viii + 148 pages, 41 figures. (1905). Cloth, $1.00.

FURMAN — *A Manual of Practical Assaying.* 8vo, viii + 467 pages. (1899.) Cloth, $3.00.

RICKETTS-MILLER — *Notes on Assaying.* 8vo, viii + 311 pages, 38 figures. (1899). Cloth, $3.00.

WILSON — *The Chlorination Process.* 12mo, v + 125 pages. (1907). Cloth, $1.50.

JOHN WILEY & SONS
43 & 45 E. 19th St., New York City

Eleventh Edition

Metallurgy of Cast Iron

A complete exposition of the processes involved in its treatment, chemically and physically, from the blast furnace through the foundry to the testing machine, being a practical compilation of original research.

By THOMAS D. WEST

Contents

PART I.—Manufacture and Use of Coke—Properties in Ores—Operations of Blast Furnaces—The Different Brands of Pig-Iron and How to Purchase and Use Them Intelligently (27 chapters). II.—Elements in Cast-Iron and Their Physical Effect—Utility of Chemical Analyses and How to Use Them in Making the Different Mixtures of Irons Used in Making Gray and Chilled Castings (21 chapters). III.—Properties of and Methods for Testing Molten Iron—Phenomena in the Actions of Cooling Metal, etc.—Results of Tests in All Kinds of Irons—Best Methods for Testing (23 chapters). APPENDIX. Selected Tables for Use in Furnace and Foundry Work.

Cloth 638 Pages 153 Illustrations Price, $3.00 net

Sent Anywhere, postpaid, for the Price by the

McGRAW PUBLISHING COMPANY

114 Liberty Street :: New York

and cost of various of the processes. Then follows a brief comparison of electric furnace processes with present metallurgical practice as to the production of pig iron, structural steel and crucible steel; the author takes a conservative stand which is practically identical with that which this journal has taken in the past. The book is concluded by a chapter on the production of various ferro-alloys in the electric furnace.

* * *

DEUTSCHES PATENTRECHT FÜR CHEMIKER. By Dr. Julius Ephraim. 608 pages. Price, in paper cover, marks 18.00 (retail price in New York, $6.00). Halle a. S.: Wilhelm Knapp. (Vol. XXV. of the German monographs on applied electrochemistry.)

This is the most voluminous of all volumes published so far in the series of German monographs on applied electrochemistry; but it does not relate strictly to electrochemistry. It is a compendium of the German patent laws with special reference to chemical inventions, the author being a chemist and patent attorney in Berlin.

One of the best features of the book is that for every legal axiom which is discussed a typical example is given from chemical engineering practice. These examples should be more useful than any lengthy explanations could possibly be to explain to the layman the essential meaning of the German patent law.

Almost all examples were selected from actual cases which came up before the German patent office and are not fictitious. But only a minority refers to electrochemical cases, the majority relating to other fields of industrial chemistry.

To those who need detailed information on the German patent law this book should certainly be of value.

* * *

THE MANUFACTURE OF METALLIC ARTICLES ELECTROLYTICALLY—ELECTRO-ENGRAVING. By Dr. W. Pfanhauser. Authorized English translation by Dr. Joseph W. Richards. 162 pages; 100 illustrations; bound in cloth. Price, $1.25. Easton, Pa.: Chemical Publishing Co.

Of the German series of Monographs on Applied Electrochemistry four volumes have so far been translated by Dr. Richards into English: Engelhardt's Electrolysis of Water, Le Blanc's Production of Chromium and its Compounds, Nissenson's Arrangement of Electrolytic Laboratories, and Pfanhauser's Manufacture of Metallic Articles Electrolytically. Dr. Pfanhauser is a manufacturer of machinery, apparatus and supplies for electrolplating and electrotyping in Vienna. For this reason it is quite natural that the descriptions of the various processes given in the book are accompanied by practical notes and estimates of the cost of operation, such as a manufacturer will naturally always make for his own purposes. They represent a first approximation, and although they refer to European conditions of labor, etc., they are also valuable in this country, since itemized cost sheets are given so that one may change single items according to local conditions.

There are fifteen chapters, dealing respectively with an historical review; baths for copper galvanoplasty; physical properties of the copper deposit; behavior of copper anodes; constants of the bath and calculation of the amount of deposit; industrial plants; particular devices for special purposes and production of uniform deposits; manufacture of metallic powders and the like; manufacture of metallic foil; production of wire, etc.; manufacture of bodies of large size; manufacture of parabolic mirrors; manufacture of tubes; electrolytic etching and electrolytic engraving.

* * *

WELLCOME'S PHOTOGRAPHIC EXPOSURE RECORD AND DIARY, 1907. 260 pages; bound in red cloth; illustrated. Price, 50 cents. New York: Burroughs Wellcome & Co.

A very handsome pocket notebook with a considerable amount of information of use for people interested in photography, especially with respect to developing and methods of determining the right time for exposures.

Electrochemical and Metallurgical Industry

VOL. V. NEW YORK, JULY, 1907. No. 7.

Electrochemical and Metallurgical Industry

With which is Incorporated Iron and Steel Magazine

Published on the first of each month by the
ELECTROCHEMICAL PUBLISHING COMPANY,
[Incorporated.]
114-118 LIBERTY STREET, NEW YORK.

J. W. RICHARDS, PH. D. ..... *President*
E. F. ROEBER, PH. D. ..... *Editor and Secretary*
C. E. WHITTLESEY ..... *Treasurer*

Subscription Price: $2 per year, postpaid to any part of the world. Single copies 25 cents.

Copyrighted, 1907, by the Electrochemical Publishing Co.

Entered as Second-Class Matter, June, 1903, at the Post-Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, JULY, 1907.

CONTENTS.

EDITORIAL 253
Forty Years of Iron-Furnace Growth 253
Developments in the Rail Trade 253
The Corrosion of Iron as an Electrochemical Phenomenon. 254
THE IRON AND STEEL MARKET 256
American Society for Testing Materials, Atlantic City Meeting 256
Toronto Meeting, American Chemical Society 257
CORRESPONDENCE:
The Townsend Cell for Chloride Electrolysis. By J. R. Crocker 258
Manufacture and Uses of Carbon Tetrachloride. By J. R. Crocker 259
Iron and Steel Institute, Annual Meeting 262
Test of an Ozonizer. By Arthur W. Ewell 264
Metallurgical Calculations. (Copper.) By J. W. Richards 266
A New Shaking Device for the Chemical Laboratory. By J. M. Camp 270
The Effect of Stress Upon Corrosion of Iron. By Wm. H. Walker 270
Héroult Electric Steel Process 272
NOTES ON ELECTROCHEMISTRY AND METALLURGY IN GREAT BRITAIN 275
ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS 278
SYNOPSIS OF PERIODICAL LITERATURE 281
RECENT METALLURGICAL PATENTS 283
A Proposed Society of Chemical Engineers 285
Repairing with Thermit 285
Large Tube Mills in the Cyanide Process 286
Multimeter and Electroplater's Voltmeter 287
A New Portable Combination Meter 287
The Welding of Copper, Brass and Bronze by the Epurite Process. 288
Autogenous Welding with the Oxy-Acetylene Blow Pipe. 288
Fertilizers from Atmospheric Nitrogen in America 289
A Portable Pyrometer for Instantaneously Taking Temperature of Molten Metals 289
Stoneware Cocks 290
NOTES 290
DIGEST OF UNITED STATES PATENTS. (Calcium Carbide) 292
NEW BOOKS 293
BOOK REVIEWS:
J. W. Richards' Metallurgical Calculations. Part II 294
C. H. Kuderer's Table of Volumes Through Air Ways 294
M. LeBlanc, W. R. Whitney and J. W. Brown's Text-book of Electrochemistry 295
Ludwig Boltzmann's Populäre Schriften 295

Forty Years of Iron Furnace Growth.

During the first six months of this year there have been completed and blown in nine absolutely new blast furnaces which have a rated capacity of 1,260,000 gross tons of pig iron per annum, having thus an average capacity of 140,000 tons each. Four of these are merchant stacks, which on account of the variety of grades they may be called upon to make, and for other reasons, are of relatively smaller capacity than the five steel works furnaces, two of these being rated at 200,000 tons each. The annual capacity of these nine furnaces, added to the producing ranks in a brief half-year, is greater than the total pig iron production of the United States in 1866 or in any previous year. In 1890 the United States produced 1,205,603 gross tons of pig iron. We have not absolutely accurate records, but have enough data to show that in 1866 there were more than 400 blast furnaces in the United States, which either produced pig iron during that year or had not been definitely abandoned. These nine new blast furnaces can make more pig iron than some 400 furnaces did only forty years ago. Blast furnace capacity is increasing very rapidly. Following the furnaces just completed there are furnaces now being built having a capacity of nearly 4,000,000 tons per annum. At the close of last year the United States was making pig iron at the rate of almost 27,000,000 tons a year, so that with furnaces since built, or which can be completed within a twelvemonth or so, there will be a capacity of very well over 30,000,000 tons a year. Excluding the relatively small charcoal stacks, there will be a productive capacity of 30,000,000 tons a year, by a smaller number of furnaces than forty years ago were required to make a million tons.

◆◆◆

Developments in the Rail Trade.

Developments since our last issue illustrate quite clearly the correctness of our contention that the matter of rail quality is to a greater degree a commercial than a metallurgical proposition. It has developed that to fill the "Cassatt specifications," which the Pennsylvania Railroad believes will give it a satisfactory rail, the rail mills demand $5 a ton premium, making the price $33 f. o. b. mill. Meanwhile the Pennsylvania rail order for 1908 delivery is held up, although nearly two months ago it was announced that it had been placed for 142,000 tons. An inspired statement contains the following naive presentation of the situation: "These new specifications on the part of the Pennsylvania have caused no friction. Steel rail manufacturers say they will manufacture any kind of a rail a railroad wants, providing the road is willing to pay a reasonable price for it."

* * *

Doubtless the rail mills can do this within all probable limits, and undoubtedly they will do it, for a reasonable price, the rail mills, incidentally, being the judges of what is a reasonable price. Clearly, there is no metallurgical but a commercial problem presented, as we maintained a month ago. The Cassatt specifications call for the cropping of 25 per cent

from the top of the ingot, increased stringency in the drop test, limitation of the amount of cold straightening required, and some minor points. Liberal cropping is not a new feature; cropping has been reduced of late, because the mills were so anxious to get out large tonnages. From the beginning the drop test of the Southern rail maker has been much more severe than that of the Northern mills, and this must not be considered a feature of open-hearth steel rail manufacture in particular, but of rail manufacture in general.

* * *

The kink in the position of the rail mills is simply that through commercial developments in the past few years the quality of rails has gone down, while the price has been maintained at $28 through thick and thin. Now their position—a strictly commercial one—is that any departure in methods of manufacture must be considered on the basis of the most recent practice, with a "reasonable" increase in the price to pay for that departure. The $5 premium asked to fill the Cassatt specifications is obviously not based upon the increase in the actual cost of manufacture. It is not a question of shop costs, but of actual profits to be derived from operating a given plant or group of plants, when there is demand for all the material the plants can turn out. At present profits in steel manufacture are very large, and to reduce the output of a plant by but a few per cent, when demand equals or exceeds the previous capacity, makes a large reduction in ultimate profits. The 25 per cent crops can be remelted in open-hearth furnaces and cast into ingots at a very small cost. In the case of nearly all Bessemer rail mills the cost of transport to the nearest open-hearth plant would be very small. It is doubtful whether in any instance the output of the open-hearth plant would not be increased somewhat by this greater use of scrap. More Bessemer pig iron and less basic pig would have to be made, and that is probably where the rub comes, but if the steel industry is afraid of impoverishing its ore mines by mining too large a proportion of the lower phosphorus ores, it must increase its basic open-hearth steel capacity and decrease its Bessemer capacity. However, with the large increases being made in open-hearth capacity, and no change in Bessemer capacity except by the abandonment of that process at Duquesne, enough is probably being done to take care of that point.

The Corrosion of Iron as an Electrochemical Phenomenon.

In this issue we print abstracts of two papers on the corrosion of iron. One was presented by Dr. A. S. Cushman, of the Department of Agriculture before the American Society of Testing Materials, and offers a new electrolytic theory of the corrosion of iron. The other, by Dr. William H. Walker, of the Massachusetts Institute of Technology, gives the results of an experimental investigation of the influence of stress on the corrosion of iron. Dr. Walker's paper can only be understood in the light of Dr. Cushman's theory, since what Dr. Walker has really measured is the influence of stress on the electrical potential of iron, so that direct proportionality between corrosion and electric potential (other fundamental conditions being equal) is presupposed. Dr. Walker's paper is acknowledged to be to a certain extent preliminary, but a careful study of the work done by him will bring out some very interesting points. Not only does he shake severely some results of former investigators, hitherto widely accepted, but the exceedingly careful and systematic method of his research emphasizes the great inherent difficulties of excluding all other influences but that of stress upon potential. The detailed account of his further researches should be awaited with great interest, since the results must be of immense importance for all engineering work using structural steel—if Dr. Cushman's fundamental electrolytic theory of corrosion is right.

* * *

Dr. Cushman's paper appears to have had a stunning effect on his audience, partly on account of the novelty of the theory, as proposed, to some extent at least in glittering paradoxes, and partly on account of the corroboration of the presented hypothesis by pretty and interesting lantern slides. On "the day after" we may coolly and critically dissect the argument and shall be pleased to find the theory sound, even if it is not found to be revolutionary. If we understand Dr. Cushman correctly, he has not suggested a purely electrolytic theory of the corrosion of iron. According to him there are two steps—the first is electrolytic, and results in a solution of iron, which thereby passes from the metallic into the ferrous ionic state; the second step is purely chemical, the oxygen in the atmosphere oxidizing the ferrous ion to ferric, and thus precipitating the insoluble red hydroxide known as rust. When Dr. Cushman makes the surprising statement that it is the hydrogen ions rather than the oxygen which are at the bottom of the rusting of iron, he evidently means only the first attack of the iron, whereby it is forced to pass into solution, and if we look at it that way there is nothing revolutionary whatever in his hypothesis. Take very pure zinc and put it into sulphuric acid, there will be practically no action, while if we use impure zinc we at once observe a strong evolution of hydrogen, zinc going simultaneously into solution. Instead of the impure zinc we may take very pure zinc and wind a few turns of platinum wire around it, the result being the same, the hydrogen being now developed at the platinum surface, while the zinc is dissolved. In the latter case we have a short-circuited galvanic cell or a galvanic couple, the zinc being the anode and the platinum the cathode, the chemical reaction being exactly the same as in the old Smee primary cell. Impure zinc behaves in exactly the same way, the only difference being that in this case the cathode—or rather, cathodes—are formed by the innumerable impurities distributed over the surface of the zinc; in this case the zinc is the seat of innumerable galvanic couples.

* * *

The reason why the zinc is dissolved with hydrogen development may be stated in different ways. On the basis of the old thermochemical views we may say that since the formation energy Zn, S, $O_4 = 248{,}000$ calories and H_2, S, $O_4 = 210{,}200$, we find that the reaction $Zn + H_2SO_4 = ZnSO_4 + H_2$ evolves 37,800 calories. According to Berthelot's principle of maximum work this reaction will go on spontaneously, because it evolves heat, and from Thomson's rule we find directly the electromotive force of the reaction to be 0.8 volt. We know that this way of looking at the matter is not strictly correct, but while the above consideration is wrong in principle, this method of calculation gives approximately correct results. To state the

principle correctly, we should not use Berthelot's rule, but the second law of thermodynamics. We should not say that the reaction goes on spontaneously because it evolves heat or (what is the same) because its total energy of reaction is positive. We should rather say that it goes on because its free energy (its capacity of performing work) is positive. However, the numerical values of the total energy and of the free energy are but little different in this case, as in most cases of practice at ordinary temperatures. Further, we should strictly apply the Helmholtz-Gibbs equation instead of Thomson's rule. But again, the numerical result is about the same. The easiest way of measuring the free energy is by measuring the potential. The potential of zinc against the hydrogen electrode is found to be 0.770 volt; in other words, the electromotive force corresponding to the free energy of the reaction which dissolves Zn with evolution of hydrogen is 0.770 volt (against 0.8 volt found above). Now we may go a step further and apply Van't Hoff's osmotic theory of solutions together with Nernst's theory of the solution pressure. By doing so, we remain strictly on the basis of the free-energy principle, but also make use of the analogy between the laws for the osmotic pressure in solutions and the pressure in gases. On this basis the reason why zinc goes into solution and hydrogen is set free is that the solution pressure of zinc overpowers the osmotic pressure of the hydrogen ions. The zinc will therefore pass into solution, but when doing so it assumes the ionic state, that means its atoms become electrically charged. Now these charges are taken over from the hydrogen ions, which therefore pass into the elementary state, the hydrogen being set free as gas or being plated out just as copper is plated out in electroplating. According to this view the solution of the zinc is the result of the presence of hydrogen ions and of the fact that the latter have a lower osmotic pressure than the solution pressure of the zinc.

* * *

We have dwelt at length on this familiar example of the dissolving of zinc in sulphuric acid, because nobody will find anything paradoxical or revolutionary in it. Yet the solution of the iron according to Dr. Cushman's hypothesis is to be considered from absolutely the same point of view. The iron goes into solution when hydrogen ions are in contact with it, because the solution pressure of iron is higher than the osmotic pressure of the hydrogen ions. There is only a quantitative but not a qualitative difference between the dissolving of iron and that of zinc. The energy of the reaction which produces an iron sulphate solution and hydrogen from sulphuric acid and iron is 24,700 calories on the basis of molecular weights, hence the corresponding e. m. f., according to Thomson's rule, is 0.5 volt. The measurement of the potential of iron against the hydrogen electrode gives 0.344 volt. If we simply substitute these figures for those which are valid for the solution of zinc we can repeat every word that was said concerning the latter problem in the preceding paragraph. It will now be understood that Dr. Cushman's statement of the hydrogen ions causing the rust must be taken *cum grano salis*, he simply means that when iron dissolves in moisture the hydrogen ions play a decisive rôle, while the formation of rust proper is subsequent, purely chemical, that is, non-electrolytic, and caused by the oxygen of the air.

In making use of his theory to prevent corrosion, Dr. Cushman points out that rusting will be inhibited if the preliminary solution of the iron is prevented. Strong alkali solutions will evidently do, since there are no hydrogen ions in the same, and the iron could not rob the alkali metal of its electric charge since the free energy of this reaction would be negative. Hence, iron will not rust in sufficiently strong alkaline solutions. A second and very interesting kind of rust inhibitors is found in strong oxidizing agents like the chromates and bichromates of potassium and sodium. This is another of Dr. Cushman's paradoxes, and is explained by him by the hypothesis that by the treatment with such reagents the iron electrode is brought into the state of an oxygen electrode. The most remarkable fact about this is that iron properly treated by this method remains permanently passive. While this is an established fact, there is something mysterious about the idea of thus producing an everlasting indestructible oxygen electrode, and we eagerly await further details on this point from the full account of Dr. Cushman's work to be published shortly as a Bulletin of the Department of Agriculture. As a whole, this work reflects high credit on its author and the Government department under the auspices of which it was done. If anybody should ask what rusting of iron has to do with agriculture, it may be explained that Dr. Cushman's work started with an investigation of the reasons underlying the rusting of fence wire. This first preliminary work was published in a Farmers' Bulletin a few years ago.

* * *

Dr. Cushman's theory suggests another thought. It is all true that the hydrogen ions play an important rôle in the dissolving of the iron, but the electrolytic action also requires some foreign material in the iron to act as cathode. Very pure zinc does not dissolve in sulphuric acid, because there are no impurities to act as cathodes, hence there are no galvanic couples. We might draw the same conclusion with respect to iron. Some corroboration of this thought may be found in some facts recorded in Dr. Cushman's fence-wire bulletin. It is a fact that with modern converter and open-hearth practice an absolutely uniform steel cannot be produced. Gases, oxides and slag cannot be entirely eliminated from the metal. To prevent pipes and blow holes, which are mainly due to iron oxides dissolved in steel, the solution of iron oxides must be prevented, and for this purpose ferro-manganese and ferro-silicon are added. This is effective, because manganese and silicon combine with the iron, but the resulting oxides are solid and remain in the steel in a finely divided state. According to the present state of the art a uniform steel free from impurities can only be produced by the crucible process or in the electric furnace. The crucible process is out of the question for general purposes. But if an electric furnace process for steel refining, such as that of Heroult can be carried out as cheaply as is claimed by its inventor to produce a uniform metal, it would certainly be worth while to test experimentally the liability of such metal to corrosion. From Dr. Cushman's theory we should expect such metal to be much more resistant to corrosion. If this is true electric furnace treatment might be found in the end to be the cheapest preventive against rusting. While this is offered only as a tentative suggestion, it should be worth while to subject it to experimental tests.

The Iron and Steel Market.

The iron and steel market became extremely dull early in June, and the most important observation that can be made now is that it has stood this dullness very well, indeed. Prices of finished steel product have shown absolutely no recession, while in pig iron the chief change has been that the abnormally heavy premiums which were being charged for small lots for prompt delivery have been reduced. The market for crude steel has declined perhaps a dollar a ton, but was abnormally high relative either to pig iron or to finished steel products.

The sentiment which has pervaded the iron and steel consuming trades during the past fortnight has been practically without precedent. There has been a marked indisposition to make fresh purchases but with no desire to cancel or postpone shipments upon previous obligations. Hitherto when buyers ceased making new commitments they began to try to evade some of their previous commitments, but that is not so in this case. There is almost as much pressure as formerly for deliveries, and furnace and mill capacity continues to be pushed to the limit. The contention so often made of late has been proved to be true, that the large volume of business on the books of furnaces and steel producers is of a vastly sounder nature than ever before. There was a time when purchases of finished steel products represented little more than options in favor of the buyer, but it is not so now.

Without a further large buying movement the iron and steel industry can operate at full pressure well into the fourth quarter of this year. It is quite possible that such a buying movement will be inaugurated; if it is not, then there will be a decided hunger for orders before this year is out, a hunger which cannot readily be appeased as capacities have grown wonderfully in this period of extreme activity, which has lasted nearly three years. It was difficult, with the then existing capacity to make 23,000,000 tons of pig iron in 1905, but the middle of 1907 finds a capacity well over 27,500,000 tons, and much additional capacity still in course of erection.

Pig Iron.

The market has been very quiet. The chief tonnage has comprised a few sales of Northern and Southern iron for delivery in the first half of 1908, and some resales of pig iron, originally purchased by Milliken Bros., who failed, and whose steel plant on Staten Island has been closed indefinitely. For this failure the heavy advance in pig iron in the past three years, relative to finished steel products, is directly responsible. The steel plant should not have been built without blast furnaces and an adequate supply of ore. Blast furnaces are fairly well sold up for the balance of the year, and a quiet market is to be expected for several months unless the market for 1908 delivery should open up in a large way. The fancy prices for small lots for prompt delivery have largely disappeared. For third quarter delivery there has been a slight recession, but fourth quarter prices are substantially unchanged. The market f. o. b. Mahoning or Shenango Valley furnace (90 cents higher delivered Pittsburg) is substantially as follows for second half delivery: Bessemer, $23.25; basic, $23.00; No. 2 foundry, $23.00; gray forge, $22.00; Southern, No. 2 foundry, f. o. b., Birmingham, is about $20.00 for second half, with $18.50 quoted for first half of 1908.

Steel.

Early in the month two or three steel mills concluded to market a larger portion of their product in the form of billets, taking the supply chiefly from their structural mills. The largest seller has marketed between 40,000 and 50,000 tons of billets through following this policy. The Steel Corporation has not appeared as a seller, being still under pressure to carry out prior obligations. The market has receded but slightly. Bessemer billets can be had, delivered Pittsburg, at $30, with open-hearth billets at $31.00 to $32.00. As the sellers are located outside of Pittsburg, delivered prices are not necessarily the Pittsburg price, plus the freight from Pittsburg, an alignment which has much prevailed in the recent past. On June 20 the Carnegie Steel Co. made its usual announcement as to the price of sheet bars on monthly and quarterly adjustment prices, naming the price for July and third quarter deliveries at $31.00, Pittsburg, for long bars. The June price was $31.00, while the second quarter price was $30.00.

Rails.

Our last report noted that some 700,000 tons of rails had been booked for 1908 delivery. The total included the Pennsylvania requirements of 142,000 tons, but since then it has developed that the announcement that the Pennsylvania order had been placed was based upon an expectation that arrangements as to specification would be made, an expectation which thus far has not been justified, since the rail mills have asked a $5.00 premium to fill the "Cassatt specifications," and the Pennsylvania order is hung up. Some additional business has been booked, and without the Pennsylvania order the total booked by all mills is now stated to be about 800,000 tons for 1908 delivery, of which some 300,000 tons comprises open-hearth rails booked by the Southern interest, almost its total capacity for the year. Demand for light rails is extremely good.

Finished Materials.

New business has materially fallen off, but there is still great pressure for deliveries. In nearly all lines mills are making much better promises for delivery of material on new orders than they were a month ago, and the gain in promises cannot be due entirely to heavy production, but must be due in large part to a more modest estimate of the requirements of customers who have long-time contracts and merely specify from time to time.

There have been no changes in prices, which stand as follow for regular mill delivery, all f. o. b., Pittsburg, plus freight to destination: Structural shapes, $1.70 for beams and channels, 15 inches and under.

Plates, $1.70 for tank quality.

Merchant steel bars, $1.60, base.

Common iron bars, $1.70, delivered Pittsburg; for Western delivery, $1.60, f. o. b. Pittsburg.

Sheets, 28 gauge, $2.60 for black, $3.75 for galvanized.

Tin plates, $3.90 for 100-pound cokes.

Freight rates on finished steel products generally, the list not including tin plates, were advanced June 1 1½ cents a hundred pounds from Pittsburg to the chief points, being now 18 cents a hundred to Chicago, 15 cents to Philadelphia, 14½ cents to Baltimore and 16 cents to New York.

American Society for Testing Materials.

The tenth annual meeting of the American Society for Testing Materials was held at Atlantic City from June 20 to 22. The convention was the best attended one in the history of the society, the number of members and guests who registered being 268. From the annual report of the executive committee it appears that the number of members has increased during the last year from 835 to 925.

The first paper presented on Thursday afternoon, June 20, dealt with business methods in the purchase of the different raw materials for a large manufacturing company, Messrs. P. H. Knight and C. E. Skinner, of the Westinghouse Electric & Manufacturing Co., being the authors. Papers concerning the purchase of coal by the United States Government and methods of sampling and testing were presented by Messrs. J. E. Woodwell, D. T. Randall, S. S. Voorhees, H. M. Wilson and R. Moldenke. The yearly coal bill of the United States Government is $6,500,000.

Mr. Robert Job presented a paper on causes of failure of cast iron in service. In his experience he has found in many cases that the difficulty was due wholly or in large part to the pres-

ence of blow holes or to porosity or sponginess of the iron and at times to the presence of considerable proportions of oxide of iron and cinder in the iron. By introducing strict specifications for the supply in the foundry with which he is connected and also introducing new methods of treating the iron in the ladle and in the cupola, so as to remove oxide of iron and blow-holes and to increase fluidity and density, he was able to achieve excellent results.

In the evening Dr. C. B. Dudley presented his presidential address, which dealt with the enforcement of specifications.

Besides various papers relating to concrete the paper of W. H. Walker and C. Dill on the influence of stress upon the corrosion of iron was read. It covered the same ground as their recent paper before the American Electrochemical Society. A full account of the results obtained by the author will be found on another page of this issue.

The Corrosion of Iron an Electrolytic Phenomenon.

Dr. A. S. Cushman, of the United States Bureau of Agriculture, discussed in an able paper the corrosion of iron. He explained why neither the carbonic acid theory nor the hydrogen peroxide theory could be regarded as adequate explanations of the rusting of iron. He presented a new thory, which considers the rusting of iron as an electrolytic phenomenon. Oxygen is not the primary cause of rusting, but hydrogen ions. The rôle of oxygen is only secondary. What really always happens when iron rusts is this: there is some short-circuited galvanic cell (due to impurities contained within and distributed throughout the iron) and hydrogen ions are set free, iron passing into solution as a ferrous ion and replacing the hydrogen. The ferrous ion is then oxidized by the oxygen in the air to ferric, and the formation of a hydrated oxide results.

All soluble inhibitors of rusting act in either of the following two ways: Alkaline solutions prevent rusting because there are no hydrogen ions in alkaline solutions. Chromic acid and its salts, which are strong oxidizing agents, prevent rusting on account of the formation of an oxygen film (not an oxide film), so that the iron becomes polarized in the sense of becoming an oxygen electrode. The author stated that a solution of potassium bicromate, not stronger than 1/600 normal, will indefinitely prevent the rusting of polished specimens of metal in cold water, even if free access of air and carbonic acid is provided for. If iron in any of its forms is immersed in strong solutions of bichromate for a few hours the surface becomes passive, even after it is removed from the solution, washed and wiped.

Since the rusting of iron is the result of the existence of galvanic couples, electric potential differences exist, and the places of cathodes and anodes can be made visible by means of a special indicator which is called by the author "ferroxyl." Agaragar and gelatin jellies impregnated with ph nol phthalein and potassium ferricyanide show red and blue nodes on specimens of iron and steel imbedded in them, the blue nodes appear where the iron is anode and is passing into solution, while the red nodes indicate cathodes. If a certain point continues to be anode for a length of time pitting occurs. The author urged that experiments should be made to try the prevention of iron rust by means of bichromate on a practical scale.

Rail Metal.

The section meetings of Friday morning dealt with matter relating to cement and to preservative coatings and paint films for metal surfaces. The session of Friday afternoon was the best attended of the whole meeting, on account of the announced discussion of new specifications for steel rails and of the troubles with rail metal. It had been expected that there would be some sharp words, but the discussion turned out to be rather a love feast, almost every speaker being satisfied with urging a stronger and heavier rail section. While for several years the railroad and the steel works members of the committee on iron and steel of the association had been unable to agree as to a rail specification an agreement has now been reached and the proposed standard specifications for steel rails will be submitted to the membership by letter ballot.

Dr. H. M. Howe, in a paper on segregation in steel ingots, discussed the question whether low-sulphur content does lessen the segregation of carbon. If low sulphur does this this fact would increase the value of the thorough desulphurizing which certain electrical processes, such as the Héroult process, bring about. Segregation is often thought of only as concentrating the sulphur and phosphorus harmfully in the upper part of the axis of the ingot, and in case of low-carbon steel this is indeed its chief reproach. But in case of high-carbon steel, segregation does the further harm of giving great irregularity of carbon content. If these electrical refining processes not only expel sulphur thoroughly, but thereby prevent or lessen the segregation of carbon, this is so much to their good. Dr. Howe has examined all available cases of segregation, about 100 in number, and the evidence of his investigation tends to show that low-sulphur content does not tend to restrain the segregation of carbon.

On the evening of Friday a complimentary dinner was tendered to the distinguished president of the society, Dr. C. B. Dudley.

At the Saturday sessions the committees on standard specifications for stay-bolt iron, on uniform speed in commercial testing and on standard methods of testing presented their reports, and papers on kindred subjects were read.

Toronto Meeting of the American Chemical Society.

The thirty-sixth general meeting of the American Chemical Society was held at Toronto, June 27-29, about 120 chemists being in attendance.

The Society was most royally entertained by the University and city of Toronto. Complimentary lunches were furnished by the University, and several garden parties and smokers contributed greatly to the enjoyment of the visiting members.

Saturday was given to an excursion to Guelph, to visit the Agricultural College.

Following the meeting on Saturday a train carrying about fifty of the members left for a three days' trip to the new mining region of Cobalt.

In addition to the general sessions of the Society there were meetings of the sections of Physical, Inorganic, Organic, Agricultural, Sanitary and Biological and Industrial Chemistry. The chairmen of the several sections presented addresses before the general sessions.

Prof. W. H. Ellis, of the section of Industrial Chemistry, was taken seriously ill just before the meeting, and was unable to be present much to the regret of every one present.

Prof. Bancroft, of Cornell University, gave an address on "Measurement of Chemical Affinity."

Frank T. Shutt spoke of "Chemistry and Canadian Agriculture," referring especially to the losses of nitrogen which virgin soils undergo on cultivation and means which have been developed to prevent any such loss.

Dr. J. Bishop Tingle, recently appointed professor at McMaster University, spoke of "American Chemical Research," especially of the development of research as indicated by the volume of publications, which remained practically stationary from '70 to '80, while it doubled in the following decade and has become, at least, three times as great during the last eight years.

Prof. C. L. Parsons, of Durham, N. H., spoke of "The Vagaries of Beryllium," a subject in which he has been especially interested and upon which he has done excellent work.

Mr. E. G. Acheson presented a paper on "Deflocculated Graphite," illustrating his address with experimental demonstration. Experiments on clays, carried out in the year 1901,

showed that by adding vegetable extracts—gallotannic acid, extract of straw—to moderately plastic weak clays, their plasticity was increased, the amount of water required to produce a given degree of fluidity was lessened, and the size of the particles in suspension was much reduced. The effect on finely divided graphite is much the same; and by the use of a little gallotanic acid and a few drops of ammonia, suspensions may be prepared which last indefinitely. Extensive tests are now being made to determine the value of this "deflocculated graphite" as a lubricant, with most encouraging results.

More than eighty papers were presented before the various sections of the Society, and abstracts of the same had been printed in advance in a very handy pamphlet, from which we take the following:

A paper by S. Avery and Mildred Parks dealt with the fixation of nitrogen in moist air by the silent electric discharge. The writers review the work of Berthelot, who concludes that the action is a catalytic one to be expressed as follows: $N_2 + H_2O + 5O = 2HNO_3$.

He lays special emphasis on the fact that no nitrous acid is formed. Following in part the work of Berthelot but working for shorter periods and using the Griess test for nitrous acid the writers found about one-tenth of the fixed nitrogen present as nitrous acid. The longer the action the less was the proportion of nitrous acid present. Any agent capable of absorbing ozone, as a piece of rubber placed in the field of the discharge, enormously increased the proportions of nitrous acid; but the observation is inconclusive as nitric acid might be reduced as well as ozone absorbed. Conducted at a temperature high enough to destroy ozone, nitrous acid is found abundantly in the cooled products but this is also inconclusive.

If a solution of nitrous acid as formed above be treated for some time with air containing ozone but no oxides of nitrogen, every trace of nitrous acid disappears.

While the results obtained are not entirely conclusive, the writers are strongly inclined to the opinion that the formation of nitric acid is due to the oxidation of lower oxides by ozone in the presence of water.

A paper by S. A. Tucker described a platinum-resistance furnace for melting points and combustions. It consists of a quartz tube, heated by a spiral of platinum tape, the whole being surrounded by infusorial earth enclosed in an asbestos box. Most excellent results on combustions and on the determination of melting points were obtained in this apparatus.

A paper by Saul Dushman dealt with copper as anode in chloride solutions. Increasing the concentration of the chloride, or rotating the anode, increases the proportion of cuprous salt formed. The experiments are in agreement with the supposition that cuprous and cupric salts are formed in such proportions that the solution at the surface of the anode is in equilibrium with metallic copper.

A paper by J. C. W. Frazer and H. N. Holmes gave the results of an experimental investigation of electric osmose. One of the conclusions reached by them from the investigation of a limited number of solutions is that the osmose for a given amount of current varies inversely as the velocity of the cation divided by its valence.

A paper by Harrison E. Patten deals with the effect of suspended particles upon the conductivity of a solution. It is shown experimentally that soil suspended in alkaline carbonate solution absorbs the electrolyte, and consequently when the soil particles are removed from the solution by centrifugal force or by settling, this absorbed electrolyte is carried down and removed from contact with the main body of the supernatant solution, whose electrical conductivity is thereby lowered to a marked degree. When these soil grains with their absorbed electrolyte are again stirred into the solution and resuspended, the conductivity of the liquid and particles is higher than that of the supernatant solution. This experiment indicates that the absorbed material is in solution, since it contributes to the electrical conductivity.

CORRESPONDENCE

The Townsend Cell for Sodium Chloride Electrolysis.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—I note in the June issue of your journal a very interesting paper by Dr. L. Backeland, describing the Townsend cell, and in reviewing the same my attention has been particularly attracted towards the high efficiencies claimed both in energy and current. These claims are made on such a basis as to excite my curiosity as to the method of their calculation.

It is a fundamental fact that the decomposition of sodium chloride requires 97,900 calories, while a dilute solution requires 96,600 calories, taken on the basis of molecular heat of formation, and since the electrical unit of energy is the Joule, equal to .238 calories, the number of joules necessary for the decomposition of sodium chloride into its constituents is 405,882 joules. Again, since the molecular weight of sodium chloride is 58.5, and 1 coulomb will decompose .0006045 grams of sodium chloride, there will be required for the 58.5 grams 96,540 coulombs, thereby requiring a vital voltage of at least 4.2 volts. This calculation is made on the supposition of direct electrolytic decomposition of sodium chloride in a comparatively dry state, and considering the matter from this standpoint it is theoretically possible to secure the highest efficiency, but it is impracticable on account of the tremendous amount of heat lost through radiation.

If the subject is viewed from the standpoint of a diluted solution, the electrolyte is bound to become a more complicated proposition. For instance, while in the first case where chlorine gas and sodium are set free the decomposition is direct, yet if the electrolyte is a dilute solution the decomposition takes place as follows:

$$NaCl = Na + Cl$$
$$H_2O + Na = NaOH + H.$$

Working on the basis of this formula, the calories necessary for the decomposition of NaCl is 96,600, the calories for H_2O are 69,000, and the calories for NaOH are 112,500. Hence, for the formation of chlorine gas, hydrogen and a caustic soda solution 53,100 calories are required. Since this figure corresponds to the passage of 96,540 coulombs, the vital voltage required is 2.29. This voltage is the pressure required for the decomposition of sodium chloride into chlorine gas, hydrogen and caustic soda. To this voltage must be added that necessary to overcome the resistance of the cell and especially that offered by the diaphragm in all cells of this character.

From "Fig. 6, Efficiency Curves" in the article, I note that the voltage necessary for the operation of the cell is quite close to 5 volts, and allowing for the high-current efficiency the writer is unable to understand how an energy efficiency averaging in the neighborhood of 68 per cent can be acquired. I should say that this should be nearer 45 per cent.

With reference to the ampere-hour efficiency, which according to the curve, I should judge to average about 98 per cent, I am unable to verify this, since the output of the cell is not mentioned. But my experience has been that under ordinary conditions it is exceptional to secure an average of 90 per cent efficiency in a diaphragm cell. Another feature which must not be overlooked is that if a high-current density is used there is bound to be quite some evolution of heat. This naturally cuts down the efficiency. I would be pleased to hear what the output of these cells is under various current densities. In that way I could verify the current efficiencies.

Another point which I note is that there is a considerable amount of salt carried over through the diaphragm. Naturally, the solution containing the salt in such large quantities requires a considerable amount of work in the vacuum pans, and unless the pans are properly constructed the salt solution with the caustic soda will have a deterimental effect upon the tubes.

J. R. Crocker.

New York City.

Manufacture and Uses of Carbon Tetrachloride.

By J. R. Crocker.

Carbon tetrachloride as a solvent has been well known to the practical chemist for a number of years, but its entrance into the commercial field has been delayed mainly by its high first cost, and, secondly, by the lack of information with sufficient proofs as to its adaptability on a commercial scale.

The recovery system in the oil, wool, fertilizer and packing house industries has arrived under the present methods at the highest point of perfection. Therefore, further improvements can only be obtained along the line of using a solvent of greater efficiency. Carbon tetrachloride has been looked upon as a possible relief in this direction. It has to its advantage over benzine and naphtha (the most common solvent at present) its ability to extract the desired product more proficiently, both in purity and brevity of time.

It is a clear, colorless liquid (sp. gr. 1.604) with an agreeable aromatic odor, free from inflammability and explosiveness, and it is known that its vapors extinguish flame. (Boiling point 78 C.) This feature is one that would meet with favor, especially where the State and Municipal laws governing fire risks by the use of benzine and naphtha are items of moment in the installation of an extracting plant.

Numerous experiments have been made on the ability of carbon tetrachloride to dissolve oils, fats, resinous pitch, coal tar, pine tar, rubber, salicylic acid, carbolic acid, bromine, iodoform, bromoform, menthal, camphor, naphthaline, sulphur chloride, soda and potash, ammonia, soaps and numerous other chemical products. As an extracting medium it shows remarkable ability in its action on fats, oils from oil seed, oil cake, animal tankage, wool, cotton and other fat-bearing materials.

Up to the present time there is, so far as the author knows, no system where its efficiency on an economical scale has been worked out on a commercial basis to prove its advantages over benzine and naphtha. What practical knowledge has been secured up to the present time has given it due credit for its great solvent powers, but its excessive cost has hindered it being taken up seriously by the manufacturers. Therefore, a few points will have to be settled definitely, and to the satisfaction of the would be consumer, before he is convinced of its adaptability over the present solvents now used. I will endeavor to put forth a few of these points.

While carbon tetrachloride will extract fats and oils quite readily in a much shorter time, and secure a much better product thereby than by the use of naphtha and benzine, there is some doubt as to the possibility of extracting the last traces, or enough, so as to make the cake from the oil seeds or fat-bearing products free from carbon tetrachloride. This is especially so where oil seed is afterwards used to feed cattle. This feature is not only one of vital importance as to the efficiency of the use of the solvent, but the excessive cost in replacing the carbon tetrachloride loss. The amount of the solvent lost in this way with the present price of carbon tetrachloride should not exceed 2 per cent, otherwise the total cost of extracting, even considering the saving both in time and labor, is more than counteracted by this loss.

It has not as yet been shown that the present users of benzine, naphtha or carbon bisulphide can safely substitute without undue alterations in their present plants the carbon tetrachloride, nor is it well known what effect carbon tetrachloride will have on the evaporators, filter presses and other machinery where the solvent in whole or part comes in contact. Take for example a film evaporator, such as the Yaryan, which at the present time is used almost entirely in the oil, grease, fat and glue business, and under conditions where benzine or naphtha is used working most satisfactorily. It would remain a question what effect carbon tetrachloride would have upon its iron or brass parts. This might be said equally so of the other machinery used in the extraction. This query has resulted in a large number of experiments being made as to the adaptability of the metals to withstand the corrosive effect of the solvent. I will set forth a few experiments made upon a small scale and their effect upon different metals.

Steel, cast iron and wrought iron are only slightly effected by carbon tetrachloride; but the presence of moisture causes decomposition, especially where the solution is in rapid circulation, and if, with the rapid circulation there is an increase of heat, the decomposition takes the form of oxide of iron and a ferric chloride. This is quite marked if the moisture is excessive; but to exclude all moisture is practically impossible. This brings up the point that carbon tetrachloride should be as near anhydrous as possible, otherwise the effect of the moisture, as explained above, will readily attack the system throughout, especially where there are a large number of joints.

It has been suggested that lead-lined or tin apparatus be used, but considering the design and construction of the machinery of an extracting plant this would not be practical. Of course, there is a tendency of the free acid fats to exert their influence towards corrosiveness. Lead, lead-antimony alloys and tin resist carbon tetrachloride under varying conditions. Copper and its various alloys and bronzes, german silver, gun metal, etc., stand the action of carbon tetrachloride, but if the temperature is high the action is marked. Zinc and alumina will stand fairly well, nickel about the same as copper; but the presence of moisture, especially if at a high temperature, is most deteriorating to all these metals. It has been found that lead and tin offer the best protection.

Although much of the above information has been collected from small experiments, there has not up to the present time been an installation upon which a sufficient amount of information of a practical nature could be secured.

However, one of the redeeming features in the use of carbon tetrachloride is the relief from fire risk, as mentioned above. This in itself will greatly aid in future research, with the idea of its introduction as a substitute for the other solvents. Again, the question of cost will be one to be thoroughly proven. Whether carbon tetrachloride at high cost and its great solvent powers, curtailed by losses during its use, can supersede the solvents now used, with their low cost but lower efficiency and danger of fire, remains to be solved by actual practical operation on a reasonable scale.

Therefore, one of the principles on which will depend the future success of carbon tetrachloride on a commercial basis will be its low cost. At its present value and with the lack of more definite knowledge as to its possibilities, the future is open for a wide and interesting line of investigation. As will be readily appreciated, the prime cost of carbon tetrachloride is governed by the cost of chlorine gas, whether direct electrolytic methods are used or chemical and electrochemical are combined.

Several attempts have been made on a small scale to produce carbon tetrachloride by the introduction of an excess of chlorine in conjunction with Dutch liquid ($C_2H_4Cl_2$) by the influence of either sunlight or artificial light approaching sunlight, and in conjunction with heat and pressure. The object was to drive off the hydrogen molecules ($C_2H_4Cl_2 + Cl_6 = C_2Cl_6 + 4HCl$); the idea being that by the introduction of an excess of hydrogen aided by heat the violent turbulation thereby would cause an excess quantity of hydrogen to remain in a nascent state in the liquid, causing an additional amount of chlorine to combine with the carbon. For it is quite necessary that there should be sufficient hydrogen to be substituted for an equal quantity of chlorine, it being a well known fact that the chlorine will invariably replace a part or a whole of the hydrogen.

The supposition was based on the following formula: $C_2H_4Cl_2 + Cl_6 = 2CCl_4 + 4HCl$. Experiments along this line were conducted for some time, both with Dutch liquid and March gas (CH_4), the March gas producing an oily mixture formed under the influence of sunlight. This oily mixture was found to con-

than [illegible] carbon tetrachloride and chloroform, but through the greater activity of the hydrogen atoms and its unstable condition in the final results proved unsatisfactory.

Another point before passage on this particular experiment, it was found that the best method to introduce the hydrogen into the Dutch liquid was under a high pressure and temperature of steam the finely divisible water molecules coming in contact with the sluggish Dutch liquid and the excess of chlorine caused the formation of $HCl + C_2H_4Cl_2 = C_2H_3Cl_3$ and $C_2H_3Cl_3 + Cl_2 = 2CCl_4 + H_2$, the hydrogen passing off as a free agent, therefore, direct combination was abandoned.

Another peculiarity about chlorine is that wherever heat is in contact with chlorinated carbon the chlorine is readily dispelled unless extra precaution is used to control and condense the escaping vapors. This is quite apparent by the reduction of trichloride of carbon (C_2Cl_6) to dichloride of carbon (C_2Cl_4) and to monochloride (C_2Cl_2).

Other methods of producing carbon tetrachloride have been introduced and tried both on a large and a small scale. In this country the carbon bisulphide process has been worked on a large scale, and attracted both producers and consumers here and abroad. I will endeavor to give a short description of same together with sketch.

It is a well-known fact that carbon tetrachloride is readily obtained by passing chlorine gas over heated carbon bisulphide (CS_2) and condensing the product in a cooler. A mixture of carbon tetrachloride and sulphur dichloride is obtained ($CS_2 + Cl_4 = CCl_4 + S_2Cl_2$), and by introducing caustic or potash into the mixture the sulphur dichloride is decomposed and dissolved, the carbon tetrachloride separating and falling to the bottom of the receptacle, being afterwards purified by distillation.

An equipment to produce carbon tetrachloride under the following formula is illustrated in Fig. 1 and described herewith.

As must be readily appreciated the chlorine gas must be as dry as possible before introduced into the presence of carbon bisulphide. To insure this the gas is first passed over sulphur, or diluted sulphuric acid and sulphur, whereby most of the moisture is extracted. The idea of introducing sulphur is not only for drying the gas but to likewise secure sulphur chloride. By this operation it is possible to secure an additional marketable product at an extremely low cost. By referring to the sketch the process can be readily followed.

The chlorine gas is introduced in pipe "A" under a slight suction. It might be well to mention that the gas can be secured either by chemical process or the more modern electrolytic process.

Passing through this pipe the gas is introduced into chamber "B" over partition "C" into chamber "D" up through tower "E," fitted with perforated plates, the gas then passing from this tower at its upper end to tower "F," descending to chamber "G," leaving through the pipe "I." The pump "H," being of a ball-piston type, carries the chlorinated sulphur liquor from the chambers "B," "D" and "G," which are connected, and distributes the same to the top of the towers in equal proportions, thereby causing a continuous circulation of the chlorinated liquor against a steady stream of the chlorine gas. As can be appreciated, after the gas has passed through this apparatus it has been thoroughly dried, and again the liquor can be circulated until it has received the proper amount of chlorination for sulphur chloride. The action will be as follows:

The chlorine gas coming in contact with the sulphur produces S_2Cl_2, the color and grade being governed by the amount of chlorine introduced. This chloride is exceedingly unstable when exposed to the sunlight. Sulphur chloride is used at present in the rubber industry in vulcanizing.

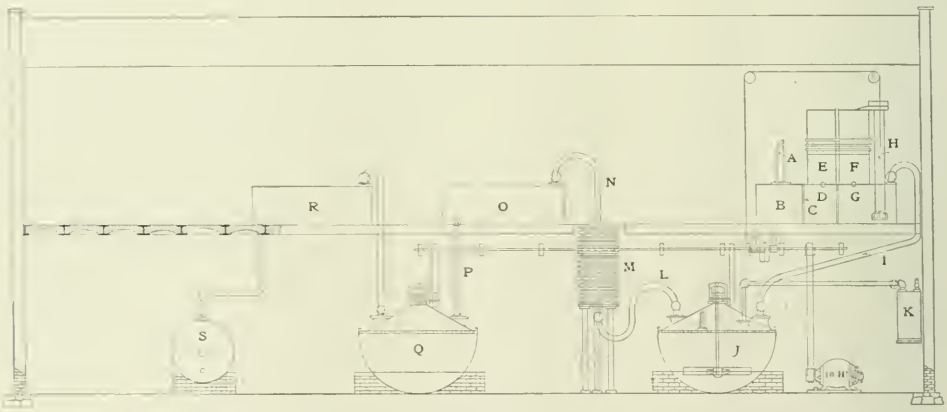


FIG. 1.—APPARATUS FOR THE PRODUCTION OF CARBON TETRACHLORIDE.

When the chlorine gas leaves the chamber "G" and passes through the pipe "I" it is brought into the caldron "J." The gas is received in this receptacle at an even and steady flow. There is likewise introduced into "J" the proper proportion of carbon bisulphide from the tank "K." It might be well to mention at this point that tank "K" acts more as a measuring tank, and it is quite advisable that the supply of carbon bisulphide located at this point be as limited as possible; since the high explosive conditions surrounding this compound would be detrimental.

To assist in the combination of the chlorine and carbon bisulphide in the caldron "J," it is fitted with an agitator driven by a line shaft located in the immediate vicinity. The caldron is also located upon a suitable foundation, so constructed as to facilitate the introduction of a heating apparatus. By the joint action of the agitator and the heating effect the chemical reaction is greatly facilitated. The regulation of the action is properly recorded by a thermometer introduced into the top of the caldron.

Immediately upon the formation of the tetrachloride gas, carrying with it a quantity of sulphur chloride, it passes through the pipe "L" into the bottom of a specially constructed catch-all "M." The object being to retard the entrainment of the liquors from "J." The gas then passes through the pipe

end into condenser "O," composed of several coils of lead pipe surrounded by cool water. The condensed gases leaving the condenser through the pipe "P" to the purifier "Q" are thereby treated by either caustic soda or lime to precipitate the sulphur chloride and impurities. This purifier is likewise fitted with an agitator.

Upon treating the solution with the alkali and drawing off the precipitate and reagitating, the gases given off are again condensed in condenser "R" of a construction similar to condenser "O." The clear anhydrous carbon tetrachloride passing from this condenser to storage tank "S" is a finished product.

As will be noted, the two products secured by this process, namely, sulphur chloride and carbon tetrachloride, are produced by the introduction of chlorine, sulphur and carbon bisulphide. Indeed, the sulphur secured from the precipitate in "J" is theoretically sufficient in quantity to be used in drying the gas in the towers "E" and "F," and producing a reasonable quantity of sulphur chloride. The reader will appreciate the fact that it is quite essential that a good pure supply is secured at the point "A." The flow of this gas through the apparatus is aided by the action of the condensing of the gases in both condenser "O" and "R."

To secure a good even flow of chlorine gas the author recommends the use of a substantial electrolytic cell, which by the decomposition of sodium chloride there will be secured both chlorine and caustic soda. The caustic soda secured still further simplifies the process by being used in the purifier as the precipitating agent in the purification of the carbon tetrachloride.

Numerous electrolytic cells have been brought to the attention of the author, who has found by a large number of tests that the points of economy both in operation and maintenance are readily secured by the McDonald cell. The author has been able to secure photographs illustrating an installation of seventy-five of these cells, which shows quite well the compactness of a plant capable of producing 1,500 pounds of chlorine per day of 24 hours, and about the same amount of caustic soda. As will be noted by referring to Fig. 2 the general arrangement of the cells facilitates their manipulation with a minimum amount of labor. In fact, a plant of this character can be operated for full 24 hours by two men. By again referring to the photographs it will be noted that the chlorine is taken from the rear end of the cells through an ordinary tile pipe where it can be readily conveyed to the carbon tetrachloride plant under a slight suction.

FIG. 3.—POWER PLANT FOR ELECTROLYTIC CHLORINE WORKS SHOWN IN FIG. 2.

Another method of producing carbon tetrachloride has been recently patented and appears to be quite feasible. The reaction rests upon the direct introduction of bleach and carbon into the vicinity of a strong electric current, the gas secured being introduced into a chamber for the purpose of condensing volatile compounds, which may be carried over from the furnace by reason of the great heat and chemical action. From there the gas passes into an ordinary condenser, leaving the same as carbon tetrachloride. The chemical reaction is best explained by the formula

$$2CaCl_2 + 5C = CCl_4 + 2C_2Ca$$

It is suggested by the author that if a very low grade of calcium chloride is used and that if chlorine gas was introduced into the effect of the fusing current at approximately the same time as both the carbon and calcium chloride come under its influence, the efficiency of this process would be materially increased. If a process of this character could be made a success it would undoubtedly be far superior to the carbon bisulphide process, as a clear solution of carbon tetrachloride would be readily secured at first hand with a minimum expenditure both in first cost of apparatus and maintenance thereof.

FIG. 2.—ELECTROLYTIC CELL FOR PRODUCTION OF CHLORINE AND CAUSTIC SODA AT PLANT OF NIAGARA ELECTRO-CHEMICAL REDUCTION & REFINING CO. (N.Y. COLORED)

Welding. — An interesting paper on the welding of structural materials in their gas presented by Harry Arthur Ruck Keene at the recent Engineering Conference of the Institution of Civil Engineers. The author gave a concise outline of three methods of electric welding of processes using the oxy-acetylene, oxy-hydrogen flame and of the aluminum thermic process, with brief notes on applications of the different methods in practice.

Iron and Steel Institute.

As noticed in our last issue the annual meeting of the Iron and Steel Institute was held in London on May 9 and 10. We herewith give abstracts of part of the papers. An account of the discussion will be found in the monthly letter of our London correspondent.

Electrically-Driven Reversing Rolling Mills, by D. Selby Bigge. Although this paper has the more ambitious title of "The Development of Electricity in the Iron and Steel Industries," it deals entirely with reversing rolling mills operated on the Ilgner system at the Hildegardehütte of Trzynietz in Austrian Silesia. The essential feature of this system lies in its fly-wheel converter sub-station, where one three-phase induction motor drives two direct-current generators, and also two heavy fly-wheels which take the momentary peak loads. The fly-wheel effect is secured by the automatic insertion of a water resistance in the rotor circuit of the main motor. The rolling mill itself is driven by three direct-current motors with shafts direct coupled on to an extension of the roll shaft; three motors being chosen instead of one, in order to limit any fly-wheel effect at this point. The motor control is secured on the Ward Leonard system. Apart from the descriptive matter the gist of the whole paper and best illustration of what the system permits is provided by a series of diagrams giving the speed voltage and current diagrams of the rolling mill motors, and the reflected load upon the generating station during the rolling of an 18-inch girder from a 2-ton ingot, which indicate that the momentary current impulses frequently reached 7,000 amps.; the energy taken from the converter has a "peak" value of 4,500 kw., while the momentary fluctuations in the reflected load on the central station only amount to 200 and 250 kw., the load gradually rising from 400 to 900 kw.

Now that the electric reversing wheel problem has been solved it is possible to electrify rolling mills throughout. The cost of electric power is, of course, an important item, but in the case of mills with blast furnaces adjacent this cost will be found to be very low, "and should in no case exceed 0.5 per cent per kw hour, while in certain cases, with modern plant and under favorable conditions, the cost of production has been brought down considerably below this figure." It is then possible in a rolling mill to entirely dispense with all coal-fired boilers and their attendant charges for firemen, conveyance of coal, removal of ashes, repairs and insurance costs. The electric power for operating the complete rolling mill, plant and accessories being primarily derived from the waste gases of the blast furnaces by means of gas-engine-driven electric generators.

Further advantages of the electrification of a rolling mill are summed up by the author as follows:

Increased output, the rolling mill motors being made to run at any desired speed direct coupled to the rolls. The speed of rolling being controlled only by considerations such as the rapid handling of the material and the mechanical strength of rolls and housings.

Extreme simplicity of the direct-coupled electric reversing mill, the whole operation of rolling, reversing and speed regulation being controlled by one lever.

Decreased cost of up-keep, as owing to the use of electric motors with their continuous rotary action and regular torque, the breakages of coupling boxes, standards, pinions and necks are reduced to a minimum.

Absolute control over rolling mill costs and power absorbed at any stage of all rolling operations, by the use of electric recording and automatic instruments, such exact control having been impossible in the case of steam.

Gain in space formerly occupied by ranges of boilers, coal bunkers, railway sidings, etc., which in some over-crowded works, or where land is high value, is an item of considerable importance.

The great reduction in power used in connection with reversing rolling mills, owing to the method of utilizing a balancing converter upon the Ilgner principle, the energy absorbed by the converter, which is derived direct from the central generating station or mains, being about one-tenth of the maximum value or torque upon the mill, even when the load fluctuates on the mill between 0 and 10,000 hp.

In the event of new mills being laid down, the ease with which the rolling mill motors can be applied direct to the rolls without the necessity of large and costly foundations, as in the case at present with heavy reciprocating steam rolling mill engines.

The very large reduction in the majority of cases of the power cost per ton of steel rolled, owing to the foregoing considerations. Less than 20 kw-hours are used per ton of blooms rolled, which in the case of mills having blast furnaces adjacent, or waste gases available, and producing electricity at 0.50 cents per kw-hour, works out at under 10 cents a ton.

Manufacture of Steel from High-Silicon Phosphoric Pig Iron by the Basic Bessemer Process, by A. Windsor Richards. In working the process some iron oxide is put into the basic converter, preferably an iron ore not too refractory, with or without a small quantity of lime, and on to this poured molten gray Cleveland iron, always low in sulphur, with silicon which may vary from 1.5 to 3 per cent. The metal is blown until all the silicon is oxidized, and the blowing continued until the appearance of the carbon flame; it is then interrupted by turning down the converter, and as much as possible of the perfectly fluid silicious slag is poured off. This slag contains 3 per cent of iron, 35 to 45 per cent silica and no phosphorus. It does not affect the linings to any appreciable extent owing to the low temperature during the first blowing, for while there is a little more corrosion on the sides of the converter a much better life is got from the bottoms, the net result being that the same quantity of dolomite per ton of steel is used now as when using basic iron. The final slag contains 8 to 11 per cent of iron, 14 to 20 per cent of phosphoric acid (95 to 100 per cent soluble in a 1 per cent solution of citric acid in water), and 11 to 12 per cent silica. Practically the whole of the iron in the oxide added for the desiliconizing is reduced and passes into the bath of metal, thus improving the yield.

The advantages of the process are thus summarized by the author: 1. An improved quality of steel, the phosphorus being under better control. 2. A high carbon steel for rails can be produced with the greatest regularity. 3. The utilization of native ironstone without foreign additions. 4. Reduced loss on blowing in consequence of less iron being ejected from the converter, less oxidation and direct reduction of a portion of the oxide of iron additions. 5. Cleanliness of working, involving less labor. 6. Rich fertilizing slag from pig iron containing 1.50 per cent or less of phosphorus.

The steel produced by this process rolls splendidly, and answers all that is required of it under the most rigid specifications, and the results obtained have effectually disposed of the theory, so long held by many, that 1 to 2 per cent of manganese, which is not only costly to add, but has to be got rid of again at great cost, is a necessary constituent of basic Bessemer iron.

Production of High-Class Steel from Pig Iron Containing Chromium, Nickel and Cobalt, by A. Windsor Richards. The paper describes a method by which a steel is produced containing approximately 1.5 per cent of nickel, with 0.25 per cent of cobalt and 0.30 per cent of chromium, from a pig iron containing 1.75 per cent of nickel and cobalt, 4 per cent of chromium and 4 per cent of silicon. Dr. Otto Massenez conceived the idea that if the iron were worked in a basic or neutral-lined, open-hearth furnace provided with slag notches the chromium might be removed by forming successive voluminous quantities of oxidizing slags, and as the chromic oxide was formed, removing these slags through the slag notches

before they become too thick. The process based on Dr. Massenez's idea was worked out at the Cleveland works by the author, and after many disappointments was finally successful, with the result that the greater part of the chromium was eliminated, but all the nickel and cobalt was retained in the steel.

Before adopting the open-hearth furnace experiments were first made in an acid Bessemer converter to determine whether chromium could be removed therein, but it was found that when only 0.4 per cent was present in the metal it was impossible to convert it owing to the extremely thick slag produced by the chromic oxide. Fluorspar was added, but this formed foamy slag and caused waste by blowing out. No better success was found by blowing the iron in a basic Bessemer converter.

The process of working consists in pouring the molten pig into an open-hearth furnace that has been charged with lime, basic slag and hematite iron ore. A thick foaming slag removed at the end of an hour carried with it part of the chromium. This operation is repeated four times for pig containing 4 per cent of chromium, after which the metal is treated like a normal open-hearth charge. The steel produced has a much higher yield point than that of normal carbon steels of similar carbon content, and possesses exceeding toughness. Tram rails tested to destruction after withstanding repeated blows alternately on the head and foot of each rail, by a 1-ton ball falling 25 feet, had pieces of the flange torn out, and at another blow split in the web, after which it took one more blow at 25 feet to effect complete fracture. Its resistance to reversal of strain is very marked. In all cases the steel has shown great improvement by being reheated, after finishing, to a temperature of 650° C. and cooling in air. In this heat treatment it is not soaked, but as soon as it attains 650 C. evenly throughout the mass, it is removed from the furnace.

An Investigation on the Use of Steam in Gas Producer Practice, by Prof. W. A. Bone and R. V. Wheeler. This lengthy paper of upwards of 31 pages represents a first instalment only of the account of a research carried out by the authors. The investigation comprised a series of five trials with a Mond gas-producer plant at a British iron and steel works. Each of the five trials extended over a full working week, with a plant supplying gas both for gas engines, for reheating and puddling furnaces all working under normal conditions. The only difference between the conditions from week to week was in the relative proportions of steam and air used in the blast for the producers which were varied by raising the steam saturation temperature of the blast in five equal stages from 60° to 80° C. Their enumeration of the general conclusions occupies some 4½ pages, from which the following chief features may be noticed:

(1) Quality and composition of the gas. The quality of the gas obtained, though always good, steadily deteriorated as the steam saturation temperature was raised beyond 65°. Thus, whereas, at 60° and 65° the average percentage of total combustibles in the gas exceeded what must be considered the high figure 47 per cent. it steadily dropped to about 42 per cent as the steam saturation temperature was raised to 80°. This fall off in quality was, it is true partly counterbalanced by an increase in the quantity produced per ton of coal gasified; but the general efficiency of the process fell off as more steam was used. Further, the advantages gained by working at the lower steam saturation temperatures become more marked when the composition of the gas is taken into account. As the steam saturation temperature was raised the gas became richer in hydrogen and carbon dioxide, but much poorer in carbon monoxide, and the gain in hydrogen was more than counterbalanced by the loss in carbonic oxide.

(2) Thermal efficiencies of the plant. If the thermal efficiencies of the plant be considered it will be found that the use of steam beyond that required to saturate the air blast at 60° was not attended by any increased economy of working, but rather the reverse. Under the conditions of the trial, therefore, the thermal efficiency of the plant fell from 71.5 to 60.4 per cent as the steam saturation temperature was raised from 60° to 80°. Hence the use of steam over and above that required to saturate the blast at 60° does not lead to higher thermal efficiencies. In the author's opinion the maximum of advantage derivable from the use of steam depends to some extent on the thickness of the fuel bed, but under such working conditions as were maintained in the trials this maximum is probably attained with a steam saturation temperature between 60° and 65°, taking all the factors into consideration.

(3) Yields of ammonia. If a gas producer be regarded primarily as an apparatus for ammonia recovery, then undoubtedly it should be worked with the highest steam saturation temperature consistent with the production of combustible gas. Probably the best steam saturation temperature, if ammonia recovery be considered in conjunction with the suitability of the gas for furnace purposes and the thermal efficiency of the process, is somewhere in the neighborhood of 65°, or possibly between 65° and 70°. At 65° over 30 per cent of the nitrogen in the coal can be recovered as ammonia, or nearly double the amount usually recovered in by-product coking processes in conjunction with a very suitable gas for furnace purposes.

Relation Between the Process of Manufcture and Some of the Physical Properties of Steel, by F. W. Harbord. For many years it has been known to all steel manufacturers and metallurgists that steels made by different processes, although practically of the same composition, varied in their tensile strength hardness and other physical properties, and it has been generally admitted that basic Bessemer steel was softer than acid Bessemer, and basic Siemens softer than acid Siemens. The author, therefore, presented a paper giving the result of numerous analytical and experimental investigations, from which are set out that in order to obtain the same physical properties each particular process requires its own special proportion of carbon.

Thus, from 30-ton steel upwards about 0.10 per cent more carbon is required in a basic open-hearth steel than in an acid Bessemer steel to give the same result, and if engineers require material of the same strength made from the basic open-hearth furnace as they have been accustomed to receive from the acid Bessemer, they must permit the manufacturer to increase his carbon approximately to this extent. The same applies in a much less degree to steel from the acid open-hearth and the basic open-hearth, but the essential point is that a reasonable increase in carbon must be permitted in order to obtain the same results. That this can safely be done is shown by practical experience, and also by the fact that the necessary elongation and reduction of area to satisfy all reasonable specifications can be obtained with this increase of carbon.

An examination of the results obtained, however, with the experimental bars shows that a basic open-hearth steel containing 0.50 per cent of carbon has the same hardness as an acid Bessemer steel containing 0.40 per cent of carbon, and that approximately, for carbons above 0.35 per cent it is necessary that the carbon should be at least 0.10 per cent higher in basic open-hearth steel than in acid Bessemer steel to obtain the same hardness.

Further, on comparing acid Bessemer rails with basic open-hearth and basic Bessemer rails tested at several works under similar conditions the results generally confirm those given. A large number of deflection tests under the drop test in the author's possession also show that the difference in deflection between acid Bessemer, basic acid and especially basic Siemens is very marked, and although owing to variations in section, etc., it has not been possible to compare and express these results in exact figures, they all confirm those obtained on the experimental bars. If, therefore, engineers wish to obtain rails of equal hardness from the basic open-hearth that they have been accustomed to from acid Bessemer steel, they must permit the manufacturer to increase the percentage of carbon to

give the required hardness, as otherwise, although the rails may satisfactorily pass all the usual tests required by the specification, flaws will soon arise under the conditions of heavy-load trains now customary serious trouble, due to spreading heads and undue wear.

American engineers, in their standard specifications, have already recognized the importance of this, and they vary their rail specifications according to the process of manufacture. Thus for acid Bessemer, 80-pound, 90-pound, 100-pound rails respectively, the percentage of carbon is 0.45 per cent to 0.55 per cent, 0.48 per cent to 0.58 per cent, and 0.50 per cent to 0.60 per cent, and for basic open-hearth, 0.50 per cent to 0.60 per cent, 0.55 per cent to 0.65 per cent and 0.58 per cent to 0.68 per cent for similar rails. This permits an increase of about 0.08 per cent of carbon for the basic open-hearth rails, but in the author's opinion it will be quite safe to allow from 0.10 per cent to 0.12 per cent increase. He thinks it quite possible that experience may show that even more than this is permissible.

The Ageing of Mild Steel, by C. E. Stromeyer. The author, whose experience in regard to steam boilers is wholly exceptional, is firmly of the opinion that some grades of steel do deteriorate with extreme suddenness, and recites in his 55-page paper numerous surprising cases. He suggests, possibly, but this has not been established, brittleness has to be initiated either by the introduction of a crystal or by application of a stress, like the application of a shearing stress to the edges of the steel plates. Related phenomena are crystallization of supersaturated solutions of salts, notably sulphate of soda. The solution is a perfectly homogeneous one, but on introducing a crystal, and thereby relieving or initiating a strain in the fluid, sudden segregation of part of the salt takes place. The well-known sudden solidification of molten phosphorus is a similar phenomenon. The slow changes which take place in solutions of carbonate of soda are analogous to some eutectic phenomena in solid metals and may help to an understanding of this difficult subject of ageing. At 10° C., 100 grams of water will dissolve 37 grams of sodium carbonate, provided it is associated with seven equivalents of water, and has crystalized in rhombohedric form. Another salt, also containing seven equivalents of water, but of rhombic form, will, at 10° C., only dissolve at the rate of 26.3: 100 of water. A distinct ageing effect can here be noticed, for apparently the former of these salts, although dissolved, slowly changes into the latter form; and if there is more than 26.3 per cent present slow precipitation of the surplus salt takes place. The seven-equivalent rhombic salt while in solution can also associate itself with another 3 per cent of water, whereby it converts itself into a salt of which at 10° C only 12.6 parts can be dissolved by 100 of water. Thus, slowly and without apparent cause soda segregates or crystallizes out of a solution which was certainly not supersaturated. Here we have a case in which time alone produce changes in the constituents of a fluid, which, if it were a solid, would become evident under the microscope as changes of structure.

Omitting the author's numerous tables, he points out that certain steels do possess ageing qualities, that some steels tend to improve with time others to deteriorate. That as yet the process which gives results which are most in harmony with practical experience is to plane the edges of two samples, to nick them with a specially prepared chisel, and then to bend one sample at once and the other after waiting some weeks or after boiling.

But despite the number of failures which he attributes to ageing, the author disclaims any desire to pose as a scaremonger. He says, "Although I am responsible for the safety of over 8,000 boilers I do not feel alarmed by the knowledge I have gained that steel and iron have ageing tendencies; for cases are brought to my notice every year in which structures have been loaded far beyond the customary limits and yet have shown no signs of giving way. These are experiences which it is difficult to explain, except on the supposition that some materials improve with age; but they naturally raise the question as to whether one cannot perceive that all materials should be of this nature, in which case many customary high factors of safety might be considerably reduced. The value, in my opinion, of the results obtained in these experiments is that they direct attention to a subject which, if followed up, may lead to an improvement of the ageing properties of steel."

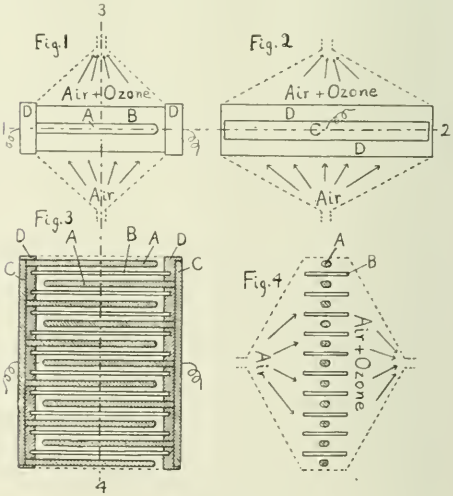
Induced Draught With Hot Air Economizers for Steel Works and Blast Furnace Boilers, by A. J. Capron. This paper describes some tests carried out with the Ellis and Eaves hot-air induced draught system at various works. Directly the paper has no distinct metallurgical interest. The tests given lack many essential details, and the paper would have been severely handled had it been read, say, at the Institution of Mechanical Engineers. But it is dubious as to whether the Council of that institution would have accepted it.

Abstracts of the balance of papers will be published in our next issue.

Test of an Ozonizer.

By Arthur W. Ewell.

A statement of the efficiency of an ozonizer should give the amount of ozone produced by a given amount of electricity and also the amount of ozone produced by a given amount of electrical energy. Both should be stated for different ozone concentrations, since the efficiency varies greatly with the concentration. The first measure of the efficiency (grams per coulomb) can easily be obtained by measuring the number of grams of ozone produced per second or minute and the electric



FIGS. 1 TO 4.—CONSTRUCTION OF OZONIZER.

current flowing through the ozonizer. The second measure of the efficiency (grams per kilowatt-hour) requires in addition to the current the potential applied to the ozonizer and the power factor if an alternating current is employed. It is difficult to measure accurately the high difference of potential applied to an ozonizer (which possesses considerable capacity), and the determination of the power factor is much more difficult, although the writer has shown an approximate method of calculation.[1]

If an alternating current is employed—and the most efficient type of ozonizer,[2] the Siemens (dielectric), requires an alter-

[1] Am. Jo. of Science, Nov., 1906. Phys. Zeitschrift, No. 25, 1906.
[2] Warburg, Ann. der Physik, 20, 1906, p. 734. Ewell, Phys. Rev., April, 1906.

nating current—the electrical energy can be determined most satisfactorily by measuring the watts at the primary of the transformer which supplies the high potential current to the ozonizer and subtracting the transformer losses. The latter must be small if the method is to be accurate, and therefore the transformer should operate the ozonizer at about its own normal potential and capacity.

The writer has recently designed and had constructed an ozonizer of such dimensions that a standard General Electric transformer (No. 27,615, 13,200-110 volts, 200 watts) would operate it efficiently. This ozonizer embodied those features which, as the writer has shown,[2] give the highest efficiency and least danger of breakdown, namely, flat, narrow, bare, electrodes with glass midway between.

The construction is outlined in Figs. 1 to 4. Fig. 3 is a section along 1-2, and Fig. 4 along 3-4. The bare electrodes A narrow in the direction of the gas current, were separated by the glass plates B, which were mounted in the insulating supports D. The actual number of electrodes was 27. The dotted lines indicate walls to confine the air current.

Between the compression pump and the ozonizer the air traversed a Junker gas meter, potassium permangate solution to remove organic matter and calcium drying columns. The air and ozone escaped from the ozonizer through a large glass tube provided with glass stop-cocks at the ends, by closing which a sample of the ozone mixture could be secured. The

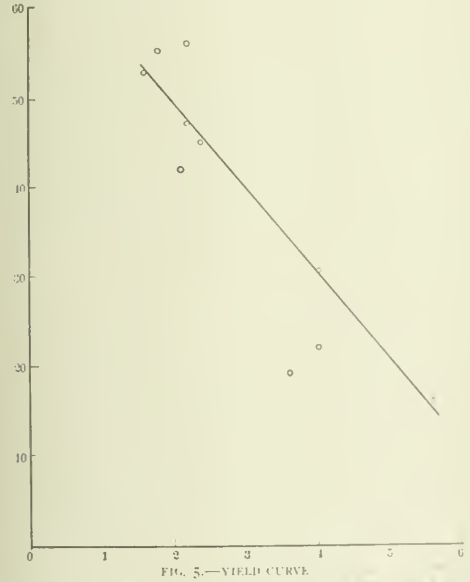


FIG. 5.—YIELD CURVE.

Horizontal axis = concentration (grams of ozone per cubic meter). Vertical axis = yield (grams of ozone per kilowatt hour). (The points below the line are for excessive currents.)

content of ozone in such a sample was determined by absorption in potassium iodide solution, acidifying and titration with sodium thiosulphite. The current flowing through the ozonizer was determined by measuring with a Kelvin electrostatic voltmeter the fall of potential across a known, non-inductive resistance. On the primary side of the transformer the potential was determined with a similar instrument, the current with a Hoyt ammeter and the watts with a Thomson wattmeter.

The experimental readings and the calculated results of the tests are given in the following table:

Primary Watts	Transformer Losses.	Current Through Ozonizer (Milliamperes)	Gas Velocity Litres per Minute	Milligrams Ozone per Minute	Concentration (Grams Ozone per Cubic Meter)	Yield (Grams Ozone per Coulomb)	Yield (Grams Ozone per Kilowatthour
113	43	9 3	24		2 1	088	42
111	43	10 5	6	22	3 6	035	19
107	40	9 1	24	52	2 2	096	47
105	40	8 6	6	24	4 0	047	22
105	40	8 6	3	17	5 6	033	16
97	40	8 3	24	53	2 2	107	56
84	36	6 8	24	41	1 8	107	55
78	32	6 5	6	24	4 0	061	31
75	31	5 7	24	39	1 6	115	53
44	24	2 7	6	15	2 4	093	45

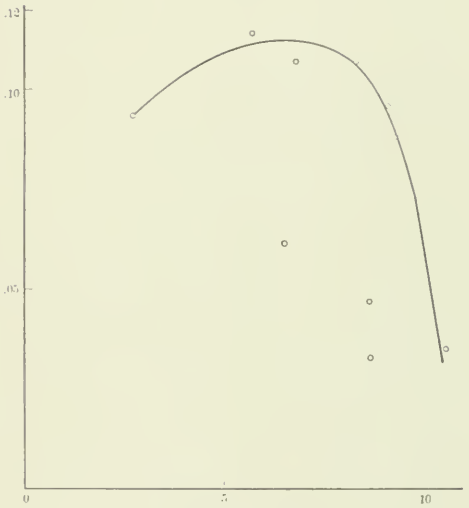


FIG. 6.—YIELD CURVE.

Horizontal axis = current through ozonizer (milliamperes), vertical axis = yield (grams of ozone per coulomb). (The points below the line are for high concentrations.)

The copper loss of the transformer never exceeded 1 watt, and therefore the losses in the table are (within 1 watt) the iron losses determined by the watts consumed when the secondary circuit was open. The yields are represented graphically in Figs. 5 and 6. From the above table it will be seen that the points below the line are in Fig. 5 for excessive currents and in Fig. 6 for high concentration. The decrease in yield in both cases is owing to the deozonizing effect of the current. A comparison of the above yields per kilowatt-hour, *for the different concentrations*, with the published tests of other ozonizers, will show the superiority of this design.

This ozonizer was designed for the Galpin Laboratories, Fifty-seventh Street and Sixth Avenue, New York City.

Worcester Polytechnic Institute, May, 1907.

Electrometallurgy. In a paper presented before the recent Engineering Conference of the (Brit.) Institution of Civil Engineers, Mr Bertram Blount remarked that "at the present there is more solid progress being made in electrometallurgy than at any previous time." As the principal electrometallurgical industries he sketches the refining of copper and the manufacture of aluminium and of sodium, but "the largest of all electrometallurgical industries will be the manufacture of steel." The Heroult and the Kjellin processes "represent two of the most distinctive and promising." "Zinc is a metal not at present smelted electrically, but which for chemical and physical reasons is excellently fitted for productions in that manner." There is much the same reason to replace the present retort furnaces by an electric furnace, as there was in the case of phosphorus and carbon bisulphide.

[2] Ewell, Phys. Rev., Feb., 1906, p. 111; April, 1906, p. 252. Reviewed in this journal, vol. 4, No. 3, p. 108. Journal of the Worcester Polytechnic Institute, Jan., 1907, p. 98.

Metallurgical Calculations.

By J. W. Richards, Ph. D.

Professor of Metallurgy in Lehigh University.

Smelting of Copper Ores.

The smelting down to matte is done either in reverberatory furnaces or in shaft furnaces. The charges are usually composed of roasted ore, roasted matte or speiss, mixed with unroasted sulphides, usually concentrates, and with siliceous rock or limestone as flux. The important reaction during the smelting down is the formation of Cu^2S by the copper present, the formation of other sulphides, mostly FeS, by the larger part of the sulphur left over, and the slagging of the elements which do not enter the matte. If much lead is present metallic lead will separate out, carrying the bulk of the precious metals, but this phenomenon will be considered under the metallurgy of lead. The important subjects for calculation are: the proportions of roasted and unroasted materials to be used, and the proportions of flux to use to make a satisfactory slag.

Some data of importance for calculations on copper smelting have been determined in the author's laboratory by Mr. Walter S. Landis.

A copper matte containing 47.3 copper, 26.2 iron and 23.6 sulphur, was found to have the following thermo-physical characteristics:

Melting point		1,000° C.
Mean specific heat, $0 - t = Sm$	$= 0.21104 -$	$0.0000366\ t$
Actual specific heat, at $t = S$	$= 0.21104 -$	$0.0000732\ t$
Heat content, solid, at 1,000°	=	174 Cal.
Heat content, liquid, at 1,000°	=	204 "
Latent heat of fusion, at 1,000°	=	30 "
Specific heat, at 1,000°	=	0.138

Heat of formation from Cu^2S and FeS not satisfactorily determined.

A copper blast furnace slag containing 35.5 SiO^2, 39.7 FeO, 1.0 MnO, 11.4 CaO, 2.7 MgO, 9.2 Al^2O^3, 0.42 Cu, 0.42 S, was found to have the following characteristics:

Melting point		1,114° C.
Mean specific heat, $0 - t = Sm$	$= 0.20185 +$	$0.0000302\ t$
Actual specific heat, at $t = S$	$= 0.20185 +$	$0.0000604\ t$
Heat content, solid, at 1,114°	=	262 Cal.
Heat content, liquid, at 1,114°	=	302 "
Latent heat of fusion, at 1,114°	=	40 "
Specific heat, at 1,114°	=	0.269

Heat of formation from its constituent oxides = 133 Calories per kg. of slag.

In the case of the slag, its melting point and latent heat of fusion are not nearly as sharply defined as those of the matte, since the matte melts sharply, but the slag goes through a pasty or viscous stage. The values given are the best approximations which could be gotten from the experiments. As regards heat of formation, the constituent oxides were carefully weighed, mixed with a known weight of carbon, and ignited in a Berthelot bomb calorimeter. Several experiments gave satisfactory concordant results, so that the heat of combination of the constituents of this slag may be taken as not far from 133 Calories per kilo. of slag. By following this scheme it is possible to measure experimentally the heat of formation of any slag whose analysis is known.

Reverberatory Smelting.

In the reverberatory furnace the atmosphere is in no case strongly reducing; it may be varied from weakly reducing to strongly oxidizing, and in the smelting operation usually averages about neutral. The consequence of this is that copper oxides or sulphate in the charge are not deoxidized by carbon, as in the shaft furnace, nor is Fe^2O^3 reduced to FeO by carbon, but the oxygen thus contained in the charge largely goes off with sulphur as SO^2, thus decreasing the amount of sulphur left to form matte, and therefore increasing the percentage of copper in the matte formed. The reactions are mainly:

$$2CuO + 2FeS + 2Fe^2O^3 + 6SiO^2 = SO^2 + Cu^2S + 6FeSiO^3.$$

The slag $FeSiO^3$ is, however, heavy and viscous; it would contain 45 per cent of silica, but runs better and gives a cleaner separation from matte if some lime is added to it. The replacement of 10 per cent of FeO in this silicate by 10 per cent of CaO lowers its melting point from 1,110° C. to 1,010°, and therefore makes a slag that is much easier to keep fluid and of greater fluidity at any given furnace temperature.

Problem 105.

Peter's (*Modern Copper Smelting*, p. 440) gives the composition of the average mixture smelted in the reverberatory furnaces at Argo, Col., as

	Per Cent.
SiO^2	33.9
Iron	10.8
$BaSO^4$	15.5
AlO^3	5.6
$CaCO^3$	8.5
$MgCO^3$	5.8
ZnO	6.1
Copper	2.0
Sulphur	5.1
Oxygen	6.4
	99.7

The furnace smelts 50 tons of this mixture (charged hot, at 350° C.) in 24 hours, using 13.5 tons of bituminous coal and producing a matte with 40 per cent of copper. Outside dimensions of furnace 20 x 40 x 6 feet. Area of stack, fire-box and hearth 16, 32.5 and 481 square feet, respectively. Temperature of stack gases 1,000° C. Composition of the coal: moisture 1.40 per cent, fixed carbon 54.90, volatile matter 32.90, ash 10.80 per cent; assume 10 per cent more air used than necessary for theoretical combustion. Temperature of slag and matte 1,200°.

Required:

(1) The weight of matte produced, assuming the slag to carry 0.2 per cent of copper (as intermingled matte), and the matte 40 per cent.

(2) The loss of copper in the slag, expressed in per cent of the total copper present.

(3) The percentage of the calorific power of the fuel existing in the stack gases, the slag and the matte.

(4) The heat lost by radiation and conduction in pound Calories per minute per square foot of furnace surface.

(5) The velocity of the hot gases at the base of the stack.

(6) The horse-power theoretically obtainable by passing the hot gases through a boiler which reduces their temperature to 200° C., and which, together with the steam engine gives a total thermomechanical efficiency of 7.5 per cent upon the heat furnished to (entering) the boiler.

Solution:

(1) The entire matte formed, that free plus that intermingled with the slag, will be per 100 of ore mixture

$$2.0 \div 0.40 = 5.0 \text{ pounds.}$$

	Pounds.
FeS in this matte $= 5.0 - 2.5$	$= 2.5$
Fe in this matte $= 2.5 \times 56/88$	$= 1.6$
Fe going to slag as FeO $= 10.8 - 1.6$	$= 9.2$
FeO in slag $= 9.2 \times 72/56$	$= 11.8$
Constituents of slag:	
SiO^2	$= 33.9$
FeO	$= 11.8$
$BaO = 15.5 \times 153/233$	$= 5.9$
Al^2O^3	$= 5.6$
$CaO = 8.5 \times 56/100$	$= 4.8$

MgO = 5.8 × 40/84	=	2.8
ZnO	=	6.1
Weight of slag	=	70.9
Copper in slag as intermingled matte	=	0.14
Intermingled matte lost in slag	=	0.35
Free matte obtained = 5.0 — 0.35	=	4.65 (1)

(2) $\frac{0.14}{2.00} = 0.07 = 7$ per cent. (2)

(3) The calorific power of the fuel may be calculated from its proximate analysis by the method of Goutal (ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, April, 1907, p. 145), as follows:

Pure fuel 1.0000 — 0.1220	=	0.8780
Per cent of this volatile $\frac{0.3290}{0.8780}$	=	37.5 per cent.
Calorific power of volatile matter	=	8,650 Cal.
Calorific power (to liquid H^2O):		
Carbon 0.5490 × 8,100	=	4,447 "
Vol. matter 0.3290 × 8,650	=	2,846 "
Sum	=	7,293 "
Water formed = 0.45		
Latent heat of vaporization of water = 0.45 × 606.5	=	273 "
Metallurgical calorific power	=	7,020 "

Assuming the volatile matter to be 15 per cent hydrogen, 40 per cent oxygen and 45 per cent carbon, the coal contains:

Hydrogen 0.329 × 0.15	= 0.049
Volatile carbon 0.329 × 0.45	= 0.148
Fixed carbon	= 0.549
Total carbon	= 0.697

and the air necessary for combustion and products therefrom are per unit weight of fuel used:

Oxygen for C = 0.697 × 8/3	=	1.859 pounds.
Oxygen for H = 0.049 × 8	=	0.392 "
Sum	=	2.251 "
Oxygen in coal = 0.329 × 0.40	=	0.132 "
Oxygen needed from air	=	2.119 "
Air needed $= \frac{2.119 \times 13/3 \times 16}{1.293}$	=	113.7 ft³.
Nitrogen therein = 113.7 × 0.792	=	90.0 "
10 per cent surplus air	=	11.4 "
Volume of $CO^2 = \frac{2.556 \times 16}{1.98}$	=	20.7 "
Volume of $H^2O = \frac{0.455 \times 16}{0.81}$	=	9.0 "

Assuming the tons mentioned are of 2,000 pounds each, the heat generated per 27,000 pounds of fuel used per day is

27,000 × 7,020 = 189,540,000 pound Calories,

and, therefore, per 100 pounds of ore smelted:

189,540,000 ÷ 1,000 = 189,540 pound Calories.

The fuel used per 100 pounds of ore being 54 pounds, the products of combustion are 54 times the above calculated volumes, to which must be added

7.4 pounds $SO^2 = (7.4 \times 16) \div 2.88$	=	41 cubic feet
6.0 pounds $SO^3 = (6.0 \times 16) \div 3.60$	=	27 " "
6.7 pounds $SO^2 = (6.7 \times 16) \div 1.98$	=	54 "

found later to be driven off the charge. The stack gases and the heat carried out by them are as follows:

CO^2	613 × 0.59 × 1,000	=	361,670 ounce Cal.
H^2O	243 × 0.49 × 1,000	=	119,070 " "
N^2 / Air	3.738 × 0.33 × 1,000	=	903,540 " "
SO^2	41 × 0.66 × 1,000	=	27,060 " "
SO^3	27 × 0.58 × 1,000	=	15,660 " "
		=	1,427,000 " "
		=	89,200 pound Cal.

Proportion of the calorific power of the fuel in the hot gases:

$\frac{89,200}{189,540} = 0.47 = 47$ per cent. (3)

To find the heat in the slag tapped, taking Landis's determination of 302 Calories in slag melted at its melting point, 1,114°, and assuming a specific heat in the melted state of 0.27, we have the heat in it per unit weight at 1,200°:

302 + (0.27 × 86) = 325 Cal.

Heat in total slag:

325 × 70.9 = 23,045 Cal.

Proportion of calorific power of fuel in hot slag:

$\frac{23,045}{189,540} = 0.121 = 12.1$ per cent. (3)

To find the heat in the matte, we may take Landis's determination of 204 Calories in matte just melted at 1,000°, and assuming a specific heat of 0.14 we have heat in unit weight at 1,200°:

204 + (0.14 × 200) = 232 Cal.

And, therefore, heat in the matte formed:

4.65 × 232 = 1,080 Cal.

Proportion of calorific power of fuel in melted matte:

$\frac{1,080}{189,540} = 0.006 = 0.6$ per cent. (3)

(4) The heat lost by radiation and conduction equals all the heat brought in and generated by combustion and other chemical reactions in the furnace, minus that absorbed by chemical reactions in the furnace, and minus that issuing as sensible heat in the stack gases, slag and matte. The ore mixture being charged hot, at 350° C., and having an assumed specific heat of 0.15, its sensible heat is

	Calories.
100 × 0.15 × 350	= 5,250
Add heat of combustion of coal	= 189,540
Heat available	= 194,790

The heats of chemical reaction of sulphates and oxides on sulphides are quite complex, and we will show the calculation in detail at the end of the problem. Suffice here to give the end results of the calculation.

	Calories
Chemical reactions, net *absorption*	16,480
Heat of formation of slag, *evolved*	+ 9,430
Net heat *absorbed* in reactions and combinations	7,050

The heat balance sheet will therefore show

Available

	Calories
Heat in hot charges	5,250
Heat of combustion of coal	189,540
	194,790

Distribution

In chimney gases	89,200
In liquid slag, tapped out	23,045

In liquid matte, tapped out	1,080
Absorbed in reactions and combinations	7,050
Loss by radiation and conduction.....	74,425
	194,790

The loss by radiation and conduction per day will be:

	Calories.
$74,425 \times 270$	$= 20,093,000$
per minute $20,093,000 \div 1,440$	$= 14,000$

The whole outside area of the furnace, including the base, is

$$(20 \times 40) + 2(6 \times 40) + 2(6 \times 20) = 2,320 \text{ sq. ft.}$$

Loss in pound Calories per square foot of surface per minute:

$$14,000 \div 2,320 = 6.0 \text{ pound Cal.}$$

(5) The volume of stack gases, at 0° C., has been found to be 3,662 cubic feet per 100 pounds of fuel used, or $3,662 \times 270 = 988,740$ cubic feet per day $= 11.4$ cubic feet per second. At 1,000° this volume would be

$$11.4 \times (1,000 + 273) \div 273 = 53.2 \text{ cubic feet.}$$

And since the area of stack cross-section is 16 square feet the velocity of the hot gases entering the stack is

$$53.2 \div 16 = 3.3 \text{ feet per second.} \qquad (5)$$

This is a low velocity, and shows good design, which will result in better economy of fuel than if high velocity were used.

(6) The gases were found to contain 89,200 pound Cal. per 100 of ore smelted, or per day:

$$89,200 \times 1,000 = 89,200,000 \text{ pound Cal.}$$

per hour $= 3,717,000$ " "

Since 1 hp. equals 1,400 pound Cal. per hour, we have:

Horse-power at 100 per cent efficiency:

$$3,717,000 \div 1,400 = 2,650$$

Horse-power at 7.5 per cent efficiency:

$$2,650 \times 0.075 = 199 \text{ H. P.} \qquad (6)$$

In connection with requirement (3) of above problem it will be interesting and instructive to discuss the chemical and especially the thermochemical phenomena accompanying the smelting down of the ore mixture. The discussion will be clearest if we take the actual figures of the problem in question.

Aside from the SiO^2, AlO^3, etc., the ore mixture contains

	Per Cent
Fe	10.8
Cu	2.0
S	5.1
O	6.4

And these four ingredients are present either as FeS, FeO, Fe^2O^3, $FeSO^4$, Cu^2S, Cu^2O, CuO or $CuSO^4$. With the above quantities of the four elements in question, however, the manner in which they are combined is fixed within rather narrow limits. Each of the four binds each of the others, and it can be found, by some patience and trying out, that the four elements, constituting 23.4 per cent of the ore mixture, must be combined about as follows in order to be present in the quantities given:

	Per Cent.
CuO	1.0
$CuSO^4$	3.0
FeS	7.3
$FeSO^4$	8.9
FeO	0.4
Fe^2O^3	3.7

The best proof of this statement is to resolve the weights of these compounds into their components, and to thus prove that they agree with the premises.

On melting this down to 40 per cent matte we produce

Cu^2S	2.5 per cent in matte.
FeS	2.5 per cent in matte.
SO^2	7.4 per cent in gases.
FeO	11.8 per cent to slag.

The heat represented by the formation of the products must be subtracted from the heat of formation of the materials reacting to get the net heat of the reaction. We will multiply the amount of each material by the heat of formation of unit weight from its elements as follows:

				Cal.
CuO	$1.0 \times (37,700 \div 79.6)$	$= 1.0 \times$	473 $=$	473
$CuSO^4$	$3.0 \times (181,700 \div 159.6)$	$= 3.0 \times$	1,139 $=$	3,417
FeS	$7.3 \times (24,000 \div 88)$	$= 7.3 \times$	273 $=$	1,993
$FeSO^4$	$8.9 \times (214,500 \div 152)$	$= 8.9 \times$	1,411 $=$	12,558
FeO	$0.4 \times (65,700 \div 72)$	$= 0.4 \times$	913 $=$	365
Fe^2O^3	$3.7 \times (195,000 \div 160)$	$= 3.7 \times$	1,223 $=$	4,525
			Sum $=$	23,331

Heat of formation of products:

Cu^2S	$2.5 \times (20,300 \div 159)$	$= 2.5 \times$	128 $=$	320
FeS	$2.5 \times (24,000 \div 88)$	$= 2.5 \times$	273 $=$	683
SO^2	$7.4 \times (69,200 \div 64)$	$= 7.4 \times$	1,082 $=$	8,007
FeO	$11.8 \times (65,700 \div 72)$	$= 11.8 \times$	913 $=$	10,773
			Sum $=$	10,782
			Difference, heat absorbed $=$	3,549

We have, therefore, a deficit, or heat to be supplied. This deficit is increased by the heat required to decompose $BaSO^4$ into BaO and SO^2, $CaCO^3$ into CaO and CO^2 and $MgCO^3$ into MgO and SO^2; while it is decreased by the heat of combination of Cu^2S and FeS to form matte, and the heat of combination of SiO^2 with BaO, AlO^3, CaO, MgO, ZnO and FeO to form slag.

The driving off of SO^3 and CO^2 absorbs

	Calories.
SO^3 from BaO, SO^3 $6.0 \times 1,189$	$= 7,134$
CO^2 from CaO, CO^2 $3.7 \times 1,026$	$= 3,796$
CO^2 from MgO, CO^2 3.0×666	$= 1,998$
Sum	$= 12,928$

The net result of all these reactions, leaving out the formation heat of the slag from its oxide constituents, is

	Lb. Cal.
Absorbed $23,331 + 12,928$	$= 36,260$
Evolved	19,780
Deficit	16,480

And even if we credit the heat of formation of the slag:

	Lb. Cal.
70.9×133	$= 9,430$

there remains a net deficit of 7,050

The reaction of the ore mixture to form matte and slag is therefore an endothermic operation, in spite of the fact that much sulphur goes off as SO^2. The prime reason for this is that the bulk of the sulphur in the roasted ore was present as sulphate and not as sulphide.

Problem 106.

A copper blast furnace has at its disposal materials of the following compositions in percentages:

	Cu.	*Fe.*	*S.*	*SiO^2.*
Selected raw ore....	15	20	35	25
Roasted concentrates	25	35	10	12
Refinery slag.....	50	10	—	25
Limestone	CaO — 50			1

It is desired to make a matte with 50 per cent copper and a slag containing 35 per cent SiO^2, 40 per cent FeO and 15 per cent CaO, or with these ingredients in those proportions.

Required:

(1) The proportions of charge.

(2) A balance sheet showing distribution of these materials.

Solution: The foregoing conditions are those which frequently confront the copper smelter. He has at hand raw ore and roasted concentrates, whose relative quantities he can usually vary at will by simply concentrating and roasting more or less material. He has return slags from the refinery furnaces which, however, are not unlimited in quantity but bear a general relation to the weight of matte made and sent on to the further operations. Finally, the limestone can be varied at will. It will readily be seen that if the charge is fixed at a certain quantity of raw ore to start with, that there are then three variables, the quantities of the other three materials, and to fix these there are practically only two conditions to be fulfilled, the two ratios between three components of the slag. In order to make a practical solution, it is necessary to make an assumption which will practically reduce the number of variables by one, and on looking over the ground it is seen that the most rational assumption which can be made is to assume the refinery slag to bear a given relation to the weight of matte produced. Such an assumption eliminates the weight of refinery slag as a variable, and leaves us with only two variables and two conditions to fill, which makes a solution possible. Assuming the charges to be based on 100 of roasted ore, we can call the weight of roasted concentrate used X, the weight of refinery slag Y, and the weight of limestone Z, and then figure out the weight of matte produced in terms of X, Y and Z. Assuming then that the refinery slag is, say, 0.25 of the weight of matte, we have $Y = \frac{1}{4}$ (expression for weight of matte), and thus one equation between X Y and Z. The ingredients of the slag being figured out in terms of X, Y and Z, the assumed relations between FeO, CaO and SiO^2 in the slag give us two more equations between X, Y and Z, and thus all three quantities can be determined.

The provisional balance sheet, based on 100 of ore and X, Y and Z of other ingredients of the charge, will be as follows:

BALANCE SHEET.

Ore.	(100).	*Matte.*		*Slag*	
Cu	15	Cu 15			
Fe	20	Fe 7.2 + 0.14Y		FeO 16.5	− 0.18Y
S	35	S 7.8 + 0.03X + 0.26Y			
SiO^2	25			SiO^2 25.0	
R'st'd Conc.	(X).				
Cu	0.25X	Cu 0.25X			
Fe	0.35X	Fe 0.12X		FeO 0.30X	
S	0.10X	S 0.10X			
SiO^2	0.12X			SiO^2 0.12X	12
Rej. Slag.	(Y).				
Cu	0.50Y	Cu 0.50Y			
Fe	0.10Y	Fe 0.10Y			
SiO^2	0.25Y			SiO^2 0.25Y	
Limestone.	(Z).				
CaO	0.50Z			CaO 0.52Z	
SiO^2	0.01Z			SiO^2 0.01Z	

Notes on above balance sheet.

Copper in the matte	15 + 0.25 X + 0.50 Y
Weight of matte (50 per cent Cu)	30 + 0.50 X + 1.00 Y
Weight of S in matte	7.8 + 0.13 X + 0.26 Y
Weight of Fe in matte	7.2 + 0.12 X + 0.24 Y

These weights of S and Fe are therefore provided for under the column "matte," taking them from the various materials charged.

The refinery slag being assumed 0.25 of the matte, we have at once

$$Y = 0.25\ (30 + 0.50\,X + 1.00\,Y)$$
$$= 7.5 + 0.13\,X + 0.25\,Y$$

whence $Y = 10 + 0.17\,X$

That is, the refinery slag equals in weight 0.1 the ore plus 0.17 the roasted concentrates. This practically amounts to leaving the roasted concentrates and limestone as the only variables.

The problem can now be solved by summing up the ingredients of the slag as follows:

$$FeO = 16.5 - 0.18\,Y + 0.30\,X$$
$$SiO^2 = 25.0 + 0.25\,Y + 0.12\,X + 0.01\,Z$$
$$CaO = 0.5\,Z$$

or substituting $Y = 10 + 0.17\,X$

$$FeO = 14.7 + 0.27\,X$$
$$SiO^2 = 27.5 + 0.16\,X + 0.01\,Z$$
$$CaO = 0.5\,Z$$

And since the requirements of the slag are that

$$SiO^2 = \frac{35}{40}\,FeO$$

and

$$CaO = \frac{15}{40}\,FeO$$

we have:

$$27.5 + 0.16\,X + 0.01\,Z = \frac{35}{40}\,(14.7 + 0.27\,X)$$

$$0.50\,Z = \frac{15}{40}\,(14.7 + 0.27\,X)$$

whence

$$X = 195 \quad Z = 48$$

and, therefore, $Y = 43$

The final balance sheet then becomes:

BALANCE SHEET.

Ore.	(100).	*Matte.*		*Slag.*	
Cu	15	Cu 15			
Fe	20	Fe 20			
S	35	S 35			
SiO^2	25			SiO^2 25	
Rs't'd Conc.	(195).				
Cu	49	Cu 49			
Fe	68	Fe 17		FeO 66	
S	20	S 10			
SiO^2	23			SiO^2 23	
Rej. Slag.	(43.)				
Cu	22	Cu 22			
Fe	4	Fe 4			
SiO^2	11			SiO^2 11	
Limestone.	(48).				
CaO	24			CaO 24	
SiO^2	1			SiO^2 1	
		172			150

Matte	*Per Cent*	*Slag*	*Ratio.*
Cu	86 = 50	SiO^2	60 = 36
Fe	41 = 24	FeO	66 = 40
S	45 = 26	CaO	24 = 14
	172		150 (90)

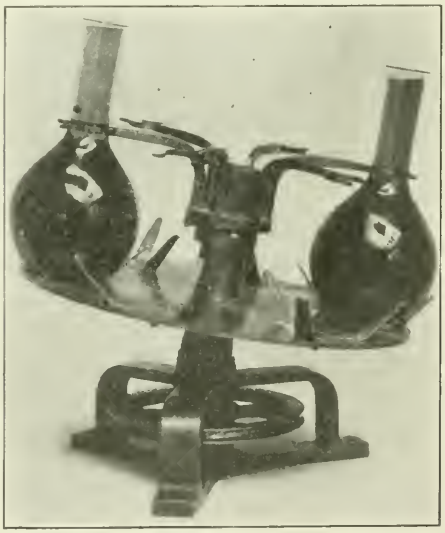
Furnace managers are usually afraid of X, Y and Z, and in regular running there is usually little need for an algebraic solution, yet many occasions arise when a judicious use of algebra solves a problem in an exact manner which hardly any amount of guessing or approximating can attain efficiently. In bringing forward this solution we may lay ourselves open to being called pedantic or academic, but the fact is that *the conditions of this problem* were proposed to the writer as a difficult nut to crack by a practical copper smelter, and the algebraic solution furnished was characterized by him as the most satisfactory solution of this class of problems which he had yet seen.

A New Shaking Device for the Chemical Laboratory.*

By J. M. Camp.

The alchemist of old failed in his search for the philosopher's stone, whose contact with the baser metals was to transmute them into the desired gold and silver. Nor has the later day chemist, for obvious reasons, found this magic pebble, but he has found the secret of changing the baser oxides into the equivalent of gold and silver. And when we compare the laboratories of the present day with those of the ancients, with their meagre supply of crude reagents, and whose apparatus included only forge-like furnaces and retorts, we cannot but marvel at their persistency in the face of such difficulties and the wonderful results they obtained.

In those days the laboratory was more like a forge shop, now it is approaching more and more to the mechanical, with its automatic samplers, grinders and stirring machines doing the manual labor, leaving the operator free for the more delicate



SHAKING DEVICE.

manipulations. And in the present day equipment to keep pace with the ever-increasing demands of the mills and furnaces, one is called upon to use every facility whereby quickness and accuracy may work together towards the accomplishment of the best results.

Among the various pieces of apparatus going to make up the equipment of the modern laboratory it is the purpose of this article to describe the latest appliance, in the shape of a shaking device. It was designed and is particularly adapted for the purpose of hastening the precipitation of phosphorus by the well known and almost exclusively used molybdic acid method, and in the solution of steels or pig irons for carbon combustion. But is equally useful where agitation is desired in a flask for either dissolving or precipitating. As can be seen from the photographs it consists of a frame supporting a vertical shaft, which is revolved by a 6-inch pulley wheel. The upper part of the shaft is bent slightly from the perpendicular. Encircling the bent portion of the shaft is a hub, which in turn supports a flat disc on which the flasks to be shaken are attached. The hub and disc are prevented from turning, when the shaft is revolved, by suitable teeth on the underside of the hub, meshing into corresponding teeth on the top of the supporting frame.

On revolving the shaft the motion of the disc is ideal for the purpose intended, and can be best likened to the simultaneous pitching and tossing of the deck of a ship in a tumultuous sea. With each revolution of the shaft a wave travels around the flask or flasks on the disc exactly as in hand shaking, and by increasing or diminishing the number of revolutions the number and intensity of the wave movement is controlled.

To obtain the maximum agitation and still retain the solutions in the flasks, without corking, from 100 to 140 r. p. m. has been found very satisfactory. The disc is made to hold six flasks, any one of which can be placed in or removed from the machine in a fraction of a second. The gripping device is movable, up or down, enabling it to be quickly adjusted to hold any size flask from a 6-ounce to a 24-ounce florence or erlenmeyer.

The electrical current required to operate it is 0.12 amp. at 250 volts, hence the power is 30 watts, or about the equivalent of the 1/25 hp.; *i. e.*, less than the average desk fan motor is consuming, so that with the proper countershaft to give the desired number of revolutions any source of power may be used.

Heat can be applied to the apparatus if desired by means of a circular burner, but it has been found that by adding the hot liquid to the flask, or heating the contents of the flask before placing it in the machine, the same end is obtained.

The advantages of the machine over hand shaking are to the chemist only too obvious. During the time of shaking the operator can be doing other more profitable work, with the assurance that aside from being relieved from the fatigue of the operation the machine is not shirking the job—as is the natural disposition of mankind—resulting in false analysis, while with the machine the reverse is the case, it is always allowed to do its full quota of work. Then under its constant conditions, in phosphorus precipitation for instance, a precipitate of like crystalization is always obtained, aiding materially its estimation by judging its bulk, as is the practice in most busy open-hearth steel works laboratories.

Too much cannot be said in praise of the machine, its simplicity, ease of operation, quietness and the readiness with which the flasks can be placed in and removed from the apparatus, and the fact that the flasks do not need to be corked with the trouble that entails, will commend it to any one. Application has been made and the claims granted for a patent covering the ideas embodied in this machine.

Duquesne, Pa.

* A paper read at a joint meeting of the Pittsburg branch of the American Chemical Society and the Chemical Section of the Engineers' Society, at the Carnegie Tech. School, on May 23. The author is the chief chemist of the Carnegie Steel Co., at Duquesne, Pa.

The Effect of Stress Upon Corrosion of Iron.

As was already briefly mentioned in our report of the Philadelphia convention of the American Electrochemical Society, an account of an elaborate research on this subject was given by Prof. William H. Walker and Mr. Colby Dill, the investigation having been made at the Research Laboratory of Technical Chemistry of the Massachusetts Institute of Technology.

In the introduction of the paper the authors consider the corrosion of iron and steel as an electrolytic effect, and assume that a definite relation exists between electromotive force and corrosion. Then the corrosion of iron in water depends essentially upon three factors. These are the electrolytic solution pressure of the iron, the electrolytic solution pressure of hydrogen and the condition of the surface of the iron or metal which is in contact with the iron, in so far as it affects the ease with which molecular hydrogen may be liberated on it (so-called excess voltage). For any given experiment the two latter factors may be held practically constant, and the electromotive

force of the system made to depend for the greater part upon the solution pressure of the iron.

The paper deals with a single one of the conditions which are supposed to influence the e. m. f. of iron; it has received considerable attention of late, namely, the effect of stress upon the metal. The authors first review critically the work of Thomas Andrews (Proc. British Inst. Civil Eng., Vol. 118, p. 356, 1894), C. Hambuechen (Bull. Univ. of Wisconsin, Engineering Series 2, No. 8, 1900), and Richards and Behr (Electromotive Force of Iron and Occluded Hydrogen, publications of Carnegie Inst. of Washington, 1906).

The investigation of the present authors was undertaken with the hope of throwing some light upon the question of the sign and magnitude of the potential changes caused by straining a piece of iron, particularly below the elastic limit. The magnitude of the increase of potential which one would expect to be produced can be easily computed on the assumption that the energy stored up in the specimen below the elastic limit is available as potential. Some very pure commercial iron (Swedish charcoal iron) was tested in the usual manner to determine the modulus of elasticity and the elastic limit. From these data the maximum amount of work which it is possible to do upon 1 cubic inch of soft iron by stretching it to its elastic limit was calculated to be 5.16-inch pounds, which is equal to 5.83 joules. One cubic inch of soft iron varies approximately 126 grams, the specific gravity being about 7.7. The work done in joules per equivalent is therefore 1.30, and the change in e. m. f. which would be expected is 1.30 joules divided by 96,540 coulombs, or 0.0000134 volt. The magnitude of this change is thus very small; its direction should be positive, because it is the manifestation of energy stored up in the metal.

The second part of the paper gives the results of experimental measurements made by the well-known method of Poggendorf, using a cadmium cell as standard e. m. f. The specimens of iron tested were made from two lots of exceptionally pure Swedish charcoal iron. One lot was of hard-drawn wire about 0.25 inch in diameter, the other was of bar iron about 0.50 inch in diameter. The bars were cut to lengths of about 18 inches, and the central portion reduced in a lathe for a distance of about 1 inch until a zone of bright new metal was exposed. This band was smoothed in the lathe first with a file and finally with emery cloth. With the exception of a narrow zone, about 0.25 inch width at the middle, the bars were covered with several water proof coatings of ordinary shellac, to insulate the metal from the solution except at the desired point.

The cell consisted of a central tube about 3 inches long and 1 inch internal diameter, open at both ends. To this were bound by means of adhesive tape three smaller tubes of the same length closed at the bottom. The bottom of the central

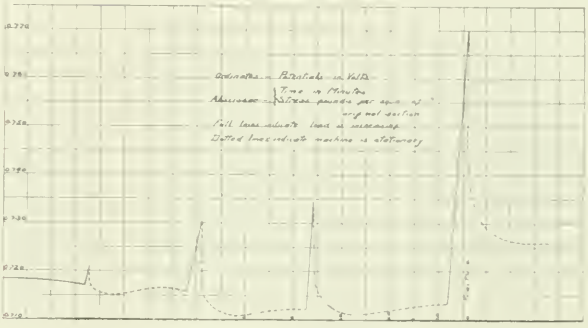


FIG. 2.—A TYPICAL RUN OF STRESS-POTENTIAL TEST.

tube was closed by a rubber stopper, carefully cleaned, through which the iron part projected, so that the reduced portion came at the middle of the tube. The central tube containing the specimen was filled with ferrous sulphate and then the three outer tubes were filled, one with ferrous sulphate and the other two with potassium chloride. All four tubes were then connected by means of siphons. The siphon of the normal calomel electrode dipped into the last KCl tube. These precautions were successful in preventing the diffusion of the $FeSO_4$ into the tube containing the normal electrode. The $FeSO_4$ solution was protected from air by a layer of paraffine oil carefully washed to remove traces of alkali or acid. Fig. 1 shows the arrangement of the apparatus used during the tests.

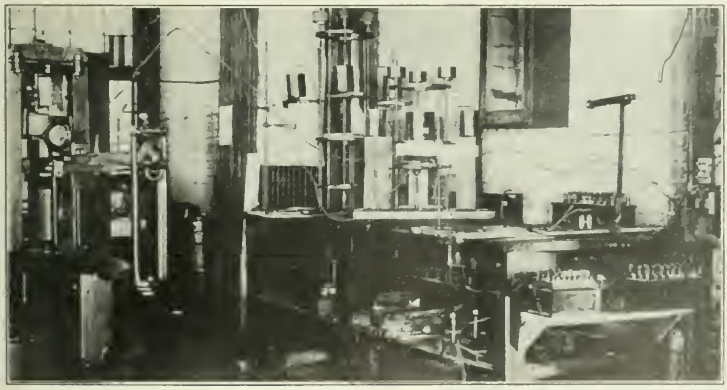


FIG. 1.—ARRANGEMENT OF APPARATUS.

Tests were made with a large number of pieces of iron which were subjected to increasing stress up to the breaking point, but it will be sufficient to give the results of one typical experiment. This is shown in Fig. 2. The curve gives directly the measured potentials in volts, the abscissæ representing the time in minutes during a test. The stress to which the iron was subjected is not given in the diagram in order to avoid complications. These figures will be given in the following description:

The stress was put on uniformly and gradually increased. The potential dropped [illegible] very slowly, until, at a stress of about 31,000 pounds per square inch of original section the e. m. f. had increased 0.9 millivolts. When the machine was stopped at this point the beam of the machine sagged. When stress was again applied the potential rose suddenly 3.9 millivolts, and when the machine was stopped it dropped to its former value in 15 seconds then sank more slowly to a minimum and then started slowly to rise again. When load was put on a second time (41,300 pounds per square inch) the character of the change was similar to the first, there being first a sharp rise of e. m. f. while the load was increas-

ing followed by an abrupt fall when the machine was stopped, then a slower fall, then a rise to a constant value. The magnitude of the sudden rise depended upon the rate at which the stress was applied. The curve in Fig. 2 shows the same behavior when stress was put on a third time (44,800 pounds per square inch), and the fourth time (up to fracture). The final value after fracture was in this experiment about 8 millivolts higher than the initial value. The arrangement of the test becomes quite evident from the diagram if one remembers that the full lines indicate that load is increasing while the dotted lines indicate that the machine is stationary.

The cause of the abnormal rise observed at high stresses was next considered. Change in temperature suggested itself as the most probable cause, although iron under these conditions has been shown to have a negative temperature coefficient. In order to duplicate as nearly as possible the thermal conditions which obtain in the iron electrode, a device was used whereby there was continual flow of heat from the electrode to the solution. A hole about ⅛ inch in diameter was drilled throughout the length of one of the electrodes. The upper end was joined by a rubber tube to a reservoir directly above, holding about 2 liters. A copper-nickel thermopile was soldered to the surface of the electrode where it was in contact with the liquid. Copper, nickel and solder were insulated from the solution by means of shellac. Hot water was placed in the reservoir and allowed to flow down through the electrode; the rate of flow was regulated by means of a screw pinchcock. The results of this test are shown in Fig. 3, from which it is evident that the rise of temperature produces a decided decrease of e. m. f. This experiment was repeated under certain precautions and entirely concordant results were obtained. This fall of potential, due to rise in temperature, explains the fact that the dotted curves in Fig. 2 fall below the normal potential of the iron bar.

FIG. 3.—INFLUENCE OF TEMPERATURE ON POTENTIAL.

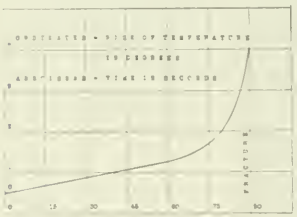


FIG. 4.—TEMPERATURE CHARGE UP TO FRACTURE.

If the sudden rise in potential above the elastic limit is caused by temperature changes in the electrode, then since iron has a negative temperature coefficient, the specimen must cool off as the breaking load is approached. Such a phenomenon, though highly improbable, is perhaps conceivable. Experiment showed, however, that there is a continuous rise in temperature from the elastic limit to the breaking load. The rise of temperature in this test was determined by means of the copper-nickel thermopile previously used. The junction was tightly bound by means of rubber bands to the reduced portion of the tension specimen. The results are shown in Fig. 4.

If there is a permanent difference in e. m. f. between a strained and an unstrained piece of metal, it should be apparent in the case of hard-drawn wire when compared with the same wire annealed. A number of samples of steel wire in its strained condition were obtained and portions of each sample carefully annealed in a vacuum. In almost every case a difference of potential was observed between the annealed and unannealed specimens. But further investigation showed that as great, and frequently greater differences, existed between the different portions of the *same wire*, both in the strained and in the annealed condition. This observation will form the basis of a subsequent communication.

The chief results of the investigation are summed up by the authors as follows:

1. The magnitude of the potential changes suffered by soft iron when tested in a tension machine below the elastic limit is exceedingly small. In the majority of cases it was less than 0.0001 volt. The maximum change was 0.0004 volt.

2. The change, when great enough to be measured, was negative, *i. e.*, the strained metal had a slightly lower potential than the same metal unstrained.

3. Somewhere above the elastic limit the potential rises suddenly several hundredths of a volt. The magnitude of the increase depends upon the rate of straining and ceases abruptly when the straining ceases.

4. Measurements upon specimens under torsional stress give results similar to those obtained from tension tests.

5. Out of a considerable number of specimens strained to breaking, the potential of six reached a constant value shortly after fracture. The difference between the initial and final potentials varied from —0.0019 volt to +0.0077 volt, and the single potential of unstrained iron was found to be 0.156 volt.

Heroult Electric Steel Process.

In numerous articles in this journal details of construction of the Héroult electric furnace have been given, so that our readers are perfectly familiar with them. We are glad to reproduce herewith a number of views of one of the largest plants now in operation in this country using the Héroult process for the production of steel of highest quality.

The steel is made in an open-hearth furnace of the familiar Wellman type and is then refined in a Héroult electric steel furnace. The daily output is 60 tons. The capacity of the open-hearth furnace is 25 tons, that of the electric furnace is

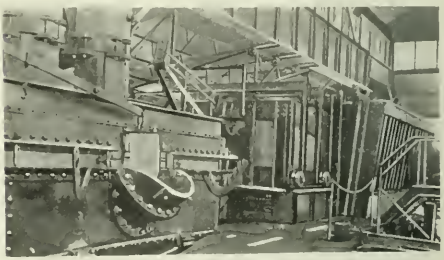


FIG. 1.—VIEW SHOWING THE OPEN-HEARTH FURNACE AT THE RIGHT AND THE ELECTRIC FURNACE AT THE LEFT.

4 tons. The open-hearth furnace works continuously. When 4 tons of molten metal are taken from the open hearth and supplied to the electric furnace, another 4 tons of scrap, etc., are charged into the open-hearth furnace. The treatment of 4 tons in the electric furnace is completed in 1½ hours.

From very exact tests made by Professor Eichhoff, he states that 200 kilowatt hours are sufficient for treating a charge of 5 tons if the overoxidized metal is supplied directly from the open-hearth furnace in molten condition to the electric furnace. If the price of the kilowatt-hour is assumed to be one-half cent—which is possible if cheap electric power is available at the steel works, for instance, from gas engines operated with blast-furnace gases—the total electrical energy necessary for the treatment of 5 tons in the electric furnace does not cost more than $1.00, or the cost of power in the electric-furnace treatment of 1 ton is not more than 20 cents.

If the charge would be supplied into the electric furnace in cold condition considerably more energy would be required, according to Eichhoff about 750 to 870 kw-hours. It is for this reason that the metal taken out from the open-hearth furnace should be furnished directly into the electric furnace with as little loss of heat as possible.

How this is accomplished in the plant illustrated in the accompanying figures is shown in Fig. 1, which gives a general

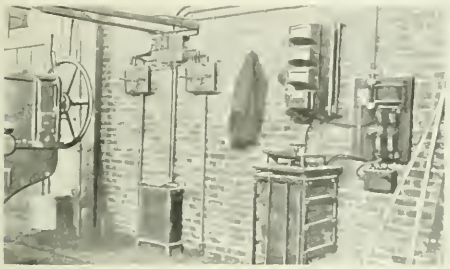


FIG. 2.—MEASURING INSTRUMENTS AND CONTROL APPARATUS.

view of the plant showing the two furnaces, side by side, close together, the open-hearth furnace at the right and the Heroult electric furnace at the left. Fig. 6 is the reproduction of another photograph taken from the other side and from a lower point; the electric furnace is again at the left and the open-hearth furnace at the right, while Fig. 5 shows the electric furnace placed high up on its platform. Fig. 4 is a front view of the electric furnace with spout, while Fig. 3 is a side view, showing at the right the apparatus for lifting or lowering the electrodes. The side door shown is used for charging and for making additions to the charge. Fig. 7 shows the electric motor and the gearing apparatus for tilting the electric furnace. Fig. 2, measuring instruments and control apparatus (from right to left main switch, the measuring instruments, and below them the rheostat switches, and at the left the apparatus for raising and lowering the electrodes, which is better shown in Fig. 3), and Fig. 8 the automatic regulator for adjusting the position of the electrodes.

While all other illustrations are self explanatory, a few words may be said concerning the automatic regulator. Since in the Héroult furnace the current passes from one electrode

FIG. 3.—SIDE VIEW OF ELECTRIC FURNACE.

into the slag on top of the metal, through the slag and out of it into the second electrode, it is important that the arcs between the end of each electrode and the slag are playing properly. If a rod of steel in contact with the molten mass (provided in the bottom of the furnace) is connected to two outside circuits, either of which leads to one electrode and contains one voltmeter, then each voltmeter is in shunt with its electrode, the arc and the fused metal and indicates whether there is the proper tension between the electrode and the metal. In other words, it indicates whether the arc is established in the proper way. A diagrammatic view of the connections was already given on page 287 of our Vol. I.). The indication of the voltmeter may, of course, be directly applied to automatic regulation of the position of the electrodes by electromagnetic means. For the principle of the method used the reader may be referred to the description of the same regulator used at the Heroult furnace in LaPraz, described on pages 5 and 6, and illustrated in Fig. 8 of Dr.

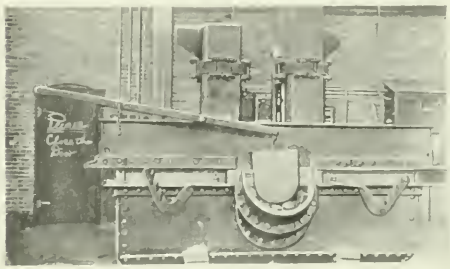


FIG. 4.—FRONT VIEW OF ELECTRIC FURNACE.

E. Haanel's report of the Canadian Commission of 1904.

Although so much has been written concerning the electrical features of construction of the Heroult furnace it seems that the essential metallurgical features of Dr. Héroult's method of working are not yet thoroughly understood. The following few notes are restricted to an explanation of the metallurgical and chemical principles of the Héroult process:

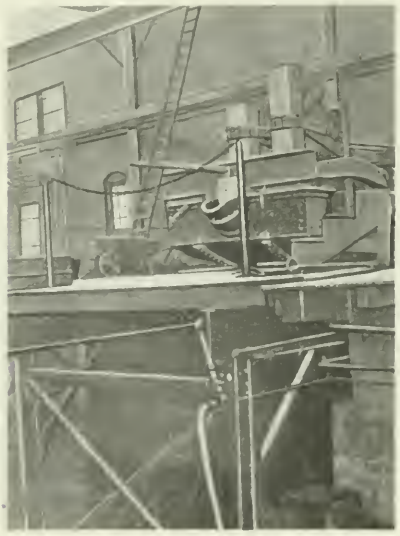


FIG. 5.—VIEW OF THE ELECTRIC FURNACE ON THE PLATFORM.

As explained before the whole process of making the steel consists of two stages: first, treatment in the open hearth furnace; second, treatment in the electric furnace, and the success, and especially the economy, of the electric treatment depends to a certain extent on the right way of carrying out the previous open-hearth treatment. The operation in the open-hearth furnace is carried out preferably further than is usual in ordinary open-hearth practice. It can be carried on so long until the phosphorus in the metal has been reduced if

desired to say, 0.005 per cent or even less. Now, it is well known that phosphorus is always eliminated after carbon. Hence, if we use the open-hearth furnace for reduction of phosphorus as far down as just stated, we necessarily also eliminate

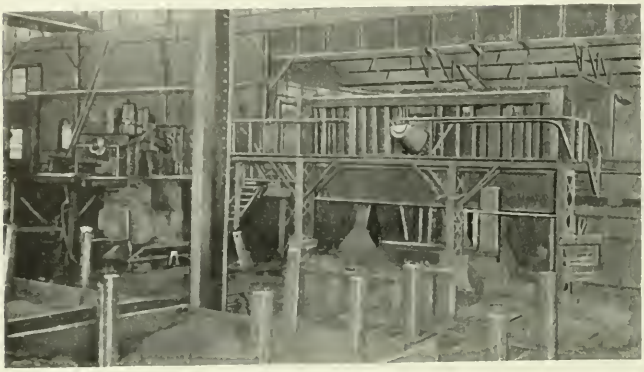


FIG. 6.—GENERAL VIEW OF THE OPEN-HEARTH FURNACE (AT THE RIGHT) AND THE ELECTRIC FURNACE (AT THE LEFT).

the carbon and at the same time highly oxidize the metal. This would be very undesirable in ordinary practice, but the product thus obtained from the open hearth is exceedingly suitable for the subsequent treatment in the electric furnace.

What is introduced into the electric furnace from the open hearth is a molten, highly oxidized metal, exceedingly low in phosphorus and carbon. What the electric furnace must accomplish is essentially the deoxidation of the metal, its recarburization and the elimmation of the sulphur. All this is attained successfully in the Héroult process, which yields a product containing any desired percentage of carbon, with less than 0.01 sulphur and phosphorus, free from oxide and slag. Prof. Eichhoff has called attention to some special chemical reactions which take place in the Héroult furnace, and only in this furnace, and which are of special interest in this connection.

The removal of sulphur is possible on account of the pos-

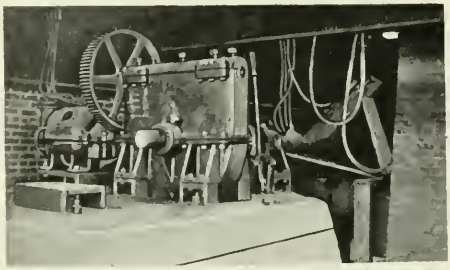


FIG. 7.—ELECTRIC MOTOR FOR TILTING THE ELECTRIC FURNACE.

sibility of selecting slags which would not be sufficiently fluid at lower temperatures but which can be used at the high temperature of the Héroult furnace. There is no danger that the charge might be spoiled by this high temperature, since the charge is continually in rapid circulation and all particles in the bath are brought into contact with the slag, the highest temperature being concentrated in the layer of slag.

With respect to deoxidation it should be emphasized that this is obtained in ordinary practice only with very great difficulty and expense. On the other hand, if iron oxides are dissolved in the steel they cause pipes and blow-holes. To prevent them ferro-manganese and ferro-silicon are ordinarily added, but while largely successful, they have the disadvantage that the resulting oxides of manganese and silicon are solid and remain in the steel in a finely divided state in form of an emulsion. Further, as long as the slag contains iron oxides in solution they will react with the molten bath, and thorough deoxidation of the bath is impossible. The neutral slag used in the Heroult furnace is perfectly free from iron, and this is a very important point.

Ferrous oxide and iron carbide can exist together, and for this reason complete deoxidation is not possible under ordinary conditions by means of adding carbon, but this is possible with the Héroult process, since the addition of carbon to the slag results in the formation of calcium carbide, and therefore the deoxidation can be carried on much further than is possible otherwise. For this reason only the least traces of ferrous oxide need be rendered harmless by means of manganese. This is introduced by adding a certain quantity of manganese ore to the slag. The metallic manganese reduced by the carbon present reduces the last traces of ferrous oxide in the bath. No reoxidation is possible, since the bath is protected by the slag from the atmosphere.

It is, of course, possible to treat in the Héroult electric steel furnace any ordinary steel made in the open hearth or converter,

FIG. 8.—AUTOMATIC REGULATORS FOR ELECTRODES.

but the phosphorus would not have been reduced to such a low percentage in the open hearth and the electric steel furnace would also have to accomplish this end. In such cases first an oxidizing slag is placed on top of the molten charge

when introduced into the electric furnace, and after it has performed its work the slag is taken off and carbon and a neutral slag is introduced as described above. Of course, in this case the electric furnace treatment consumes more time and more power, and it has been found to be economical in general to carry out the process as described before.

However, from the nature of his process, Dr. Héroult is free to carry out the preliminary open hearth treatment to any desired extent so as to make the whole treatment, that is, the combined open-hearth and electric process, as cheap as possible, so as to fit as closely as possible any case of practice.

It is apparent that in case the purposes for which the finished steel is to be used do not require the elimination of phosphorus and sulphur and the refining process to be carried out to the very highest point, as is necessary for the finest grades of tool steel, then such steel can be produced in the combination Héroult process at but a very slight cost above that of making an ordinary basic open-hearth steel, and even in the case of producing the finest grades of tool steel the additional cost of operation to reach that point is but a small item in the whole cost of production.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

The Iron and Steel Institute Meeting.

First Day.

The London meeting of the Iron and Steel Institute, which is one of the chief events of the year in metallurgical circles, was attended by the usual numerous audience. At the outset it fell upon Sir James Kitson, as senior vice-president, to induct Sir Hugh Bell to the presidential chair, it being impossible for Mr. Hadfield, the retiring president, to relinquish his honors in person owing to his absence in New York as a delegate at the opening of the Engineering Building. In introducing Sir Hugh Bell (the formal business being over) Sir James Kitson explained that real merit, and not the glory of an inherited name, was the reason for the elevation of a son of Sir Lowthian Bell to the position of president.

After presenting the Bessemer gold medal to Mr. J. A. Brinell, Sir Hugh Bell delivered a presidential address of great charm and high literary merit, which contained an appendix giving a chronological table of "some of the more important events connected with iron and steel during the past hundred years." Of the address itself the most striking part was that which discussed the relation between transport facilities and metallurgical processes, and the reactions and interactions of these forces, and the influence of the factor of intervening distance, which is becoming less and less of a barrier. Then, too, it was hinted that perhaps even the Bessemer converter was about to be superseded by the open-hearth furnace, and that a continuous process might yet displace all intermittent ones.

Passing next to the human element, it was pointed out that "those to whom were due the great improvements which ten years ago were beginning to be effected were, on the whole, men who owed little to schools or colleges. "Self-made," as the expressive phrase goes, it was to their indomitable courage and energy that they owed success; to these and to that inborn perception of the possibilities presented to them which school or college seems to do nothing to create and little to strengthen. But the first barriers broken down and the pioneers having shown the way, the carefully trained mind is needed to make straight the path. It must be admitted that we in this country have been disposed to neglect that careful training of the mind, and to rely on the native powers of insight more than on the trained intelligence. The workshop rather than the college was the technical school in Great Britain. As the tools in our possession become more complicated we must be better trained in their use. The empiric skill of the native genius, where imagination stands instead of knowledge, gives place to the learning acquired by the patient student at the technical school, and science supplants art at furnace and in workshop. If we in this kingdom are to keep our place in the world of industry we must be ready to make use of the changed methods, as our grandfathers were ready in their day to avail themselves of the forces newly placed at their disposal. For we, as they, look out on a world of perpetual change."

The vote of thanks was moved by Sir William White, who spoke of the use of steel in shipbuilding and its division into epochs, the third of which, that of high-tension steel, was now commencing. It was seconded by Mr. Schneider, of Creuzot, and after acknowledgment by Sir Hugh Bell the reading and discussion of the papers commenced. [Abstracts of the papers themselves are printed on another page of this issue.—Editor.]

Discussion on Electrically-Driven Reversing Rolling Mills.

Mr. D. Selby Bigge, with commendable brevity, did better even than the new procedure rules (which allow 10 minutes to the authors of papers) by limiting his introduction to 6 minutes.

Mr. Gledhill welcomed the paper as one of considerable importance, but in some respects depressing, as he had personally put down about five years before a 10,000-hp. triple-expansion engine for driving a reversing armor plate rolling mill. He feared the engine was obsolete, and chaffingly invited bids from the audience. No responses being forthcoming, Mr. Gledhill alluded to the intermediary links between the power house and the rolls as numerous and complicated. The matter was wholly one of economy, and the steady load afforded was one suggesting economy.

The succeeding speaker, Mr. Kerlew, was imperfectly heard, owing to his rapid delivery of a mass of figures recited at such a pace that no clear line of argument could be understood. The speaker's hostility to electric driving and frank preference for the direct coupled steam engine was, however, easily apparent.

Mr. Arthur Cooper remarked on current practice in this country, contrasting the three-high rolling mill with its heavy fly-wheel and liability to breakdown, and the reversing mill with its simple but extravagant steam engine.

Mr. Walter Dixon remarked that he was employing the Ilgner system in a case where the load conditions were not unlike those in rolling mills. The whole advantage of the Ilgner system lay in its equalization properties of rendering an intermittent demand for power a fairly continuous load at the power station. This point was further emphasized by a lecture by Mr. Robert Hammond on the importance of studying load factors. Mr. Hammond raised the only point of electrical detail by criticising the water resistance used in the control of the three-phase motor on the conversion set, and suggested that conversion should take place earlier so that direct current was used on the motor-fly-wheel-generator combination.

Mr. A. W. Richards criticised the extreme length of the Ilgner apparatus as an important drawback for existing works, and asked what capital outlay would be actually involved with the reduction in coal consumption following its adoption.

Mr. F. W. Paul remarked very bluntly that it was possible but equally futile to talk all day about pounds of steam. The methods described in the paper marked a trend in the right direction. Mill stoppages could not be obviated in steel works management. Cogging mills were idle for hours at a time. They should ask themselves in each steel works, how many mills, how are they grouped, what is the load. Then the mani-

fest ... was a central power station with its improved works ... motor.

Mr Bennett Walker and Mr Lamberton having spoken, Mr. C. H. Merz wound up the discussion by pointing out that in the first place the question was not necessarily one of steam consumption. Acceleration had to be considered, and extra rapidity of mill working would be secured. Finally, there was the case of load factor.

Mr Selby-Bigge's brief reply may be summarized as a promise to answer all the questions leveled at him in the shape of a reply at the Victoria meeting.

By this time it was too late to discuss any further papers and the meeting therefore adjourned until next day.

The Faraday Society's Meeting.

A fairly well attended meeting, with Prof. Huntingdon in the chair, on May 24, had before them two papers and a demonstration by Dr. Lowry of some new thermostatic appliances. Mr F. H. Campbell's paper, "Contributions to the Chemistry of Gold" was introduced by Mr. Wilsmore and accorded a brief discussion, the chief point being an exceeding interesting communication from Prof. Abegg, pointing out that the peroxides of the more noble metals were unstable, splitting off their oxygen at high pressure, and alluding to Dr. Cumming's recent paper on the "Electrochemistry of Lead." The point of special interest being that AuO_3 and PbO_2 had both the same hydrogen pressure. Dr. Borns remarked that Mr. Campbell had not referred to Wohlwill's work on the subject, and inquired whether the respective conclusions were in agreement. For instance, Wohlwill had emphasized the necessity for an excess of HCl. Mr Wilsmore, speaking on behalf of the author, regretted his inability to give any information beyond that contained in the paper.

Dr. F. Mollwo Perkin, speaking without any notes, gave a most interesting description of a research upon "The Reduction of Oxides and Sulphides by Metallic Calcium." As the paper has not yet been circulated an outline of its contents is perhaps not out of place. Opening with a reference to the well-known reducing action of aluminium and certain oxides in welding process, Dr. Perkin described several experiments. Desiring to obtain boron he had tried boric oxide and aluminium. These mixtures had failed to ignite, and the experiments were very uncertain, and the element's danger involved suggested to the audience (not of course, from Dr. Perkin's lips) that the hazards of the mediaeval alchemist were an unavoidable concomitant of all research upon these lines. As metallic calcium used with sodium peroxide gave a violent action, he had therefore used from 5 per cent to 10 per cent of calcium oxide and had obtained an impure amorphous boron. The impurity was calcium in the proportion of about 20 per cent. which could not be reduced to less than 20 per cent after prolonged digestion with hydrofluoric acid. Calcium was more powerful than aluminium, but very violent, and if used to reduce MnO, the action was pyrotechnically brilliant. Calcium fluoride or calcium oxide diluted the action if it was desired to reduce chromium. In order to save breaking crucibles to get out the reaction product, the crucible was lined with a paste of slaked lime and sodium silicate, which was quite successful.

Aluminium and galena in molecular proportions gave lead and aluminium sulphide. Substituting calcium for aluminium, calcium the meta-plumbate was obtained but not lead. Also, with calcium and stibnite, no metallic antimony was obtained. In conclusion, Dr. Perkin said that he was continuing his experiments, that calcium was too dear at present for commercial use, and that he hoped to obtain boron free of calcium.

In the discussion which followed, Mr. W. M. Morrison pleaded that he "had been too busy manufacturing aluminium to experiment with it." "Perhaps Dr. Goldschmidt had found some special proportions for his mixture." "Had Dr. Perkin tried an excess of boron oxide?" Dr. Borns observed that the violent action observed by Dr. Perkin had been noted ten years before. Mr. Weston said that in attempting the reduction of silicon with aluminium he had met with success by using kieselguhr and aluminium, and had obtained appreciable quantities of silicon tetrachloride. He wanted to know whether metallic calcium could be obtained in powdered form. He had recently been successful in using aluminium to reduce titanium compounds. Mr. Digby asked leave to take the discussion from the laboratory to the steel works, as he had lately been much vexed by segregation in large steel castings. Was enough known for any one to say whether metallic calcium added in small quantities to the metal in the ladle before pouring was a satisfactory remedy? This speaker was directly answered by Prof. Huntingdon who said that he did not regard the proposal very favorably as, in experiments made, the calcium oxide formed was undesirable, and occasioned other difficulties. As regards Dr. Perkin's paper, Prof. Huntingdon said it was very useful and very suggestive. The fineness and state of division of the silicon used was an important factor.

Dr. Lowry then exhibited some new thermostatic apparatus, and described the chief features of the ordinary mercury at Ostwald gas regulators. In the latter the expanding liquid was a strong solution of calcium chloride (with a coefficient of expansion equal to mercury) rising against a column of mercury. With regard to the early forms of toluene regulator the taps were a failure and would not keep tight, and therefore it was necessary to prevent the toluene coming in contact with the tap, which if kept in contact with the mercury permitted adjustments to be made. In order to have a sensitive regulator, fluted or spiral tubes were used, the latter being best. Under the control of a spiral pattern regulator, the liquid not being agitated, the temperature variations showed an extreme of 0.02° C. with a 5-minute period of oscillation. If, however, the liquid in the bath was kept in a condition of continuous movement, the variations became so minute as to be only thousands of a degree Centigrade. Usually, with all thermostats, it was necessary to reset them from day to day, and the mercury had to be kept very clean. But with a spiral pattern tube and continued movement of the water in the bath, a thermostat adjusted at 19.995° C. in October only increased its point of regulation in six months to 20.020. Water-jacketed polarimeter tubes could be regulated by controlling the water temperature in a big bath, the contents of which were well stirred; the water in the bath could be kept constantly within 1/100° C. In the form exhibited at the meeting, the loss of temperature in pumping through two thermostats was 1/100° C. per thermostat.

At the close of the demonstration, apart from the well-deserved vote of thanks, only two comments were made. Mr Wilsmore suggested that chloroform might be used instead of toluene with water on top in a safety funnel, and also mentioned Dolezalek's regulator which worked within .02° C. Dolezalek had used vigorous stirring. Dr. Cumming said that at Edinburgh he had seen an electric glow lamp inside a bath used instead of gas. Its chief disadvantage seemed to be that it had to be controlled on a shunt.

The Finances of the British Aluminium Co., Ltd.

The report of the directors of the British Aluminium Co. showed the profit for 1906 to be £155,023.13.6 with £3,880.1.11 from the previous year, the total available profit being £158,-903.15.5. The directors recommend payment of a final dividend on the preference shares for 1906, interest on the funding certificates for 1906, 5 per cent interest on the conversion shares to Dec. 31, 1906, and a dividend of 7 per cent on the ordinary shares for 1906, leaving £34,548.11.9 to be carried forward. During the year progress has been made with the development of the Loch Leven power scheme. By Aug. 15, 1908, all the generating plant should be installed and the aluminium factory erected and equipped. With a view to obtaining an increased production of aluminium prior to the completion of the Leven

works the board acquired a partially developed power at Stangfjord in Norway, and took steps to develop some 3,000 hp. at Leven, which latter can be utilized without interfering with the progress of the main chance. It is expected that the production of aluminium will commence in Norway in a few weeks' time and at Leven in the autumn. The board has also acquired concessions for a water power of considerable magnitude at Orsières, in Switzerland, and intends to proceed with the construction of works without delay. These extensions involve large expenditure, and the share capital has been increased by £600,000. An agreement has been come to with the Soc. Anon. Pour l'Industrie de Neuhausen to end all outstanding provisions of the 1895 contract upon paying to the Neuhausen Co. £100, and engaging for a maximum period of ten years, from Jan. 1, 1907, not to use or permit to be used any part of the Orsières water power for the production of aluminium.

Institution of Mining and Metallurgy

Copper Smelting.

Prof. Gowland's inaugural presidential address to the Institution of Mining and Metallurgy was an excellent example of an address of monograph order, epitomizing, as it did, "The Chief Advances in Copper Smelting in Modern Times." Naturally, it embraced many fields, and surprising, indeed, has been the transition from the time when Great Britain was the chief copper producing country in the world. Opening with statistical data, Prof. Gowland traced the growth of the world's total production from 56,200 tons in 1854 to 680,277 tons in 1905, a development due to the following features: A remarkable increase in the size and capacity of the furnaces employed, whether reverberatory or shaft; the application of the Bessemer process to copper mattes; the introduction of raw sulphide or pyritic smelting, and the reduction in the costs of producing the metal, which have followed and are dependent on the foregoing, and last, but not least, the removal of the chief producing centers from the old world to the new.

Methods of calcination, types of blast furnaces were described in detail, some vivid Japanese drawings being reproduced as typical of a rudeness of manufacturing method approaching the prehistoric. Pyrite smelting reverberatory furnace and Bessemerizing were described in detail. As to the future of this important industry it is perhaps best to quote Prof. Gowland's exact words.

"Advances as great or perhaps greater than those of the last fifty years will be made before the end of the next half century, and although it is impossible for us to foresee in what direction they will ultimately be, yet, so far as present indications are concerned, I think we may, with some degree of reason, consider that the following at least will play a not unimportant part:

"(a) The extended application of producer gas as fuel in copper reverberatory furnaces. This would, I feel sure, be found to be specially efficacious with large furnaces such as those of the Anaconda Co. Gas could be admitted at several points in their sides and so secure a uniformly high temperature throughout their length.

"(b) The introduction of the tilting furnace of the open hearth steel manufacturer into the copper refinery. A movement in this direction has already been made at the Tacoma Refinery, Puget Sound, but oil and not gas is used as fuel.

"(c) The extended adaptation of the Bessemer converter to the treatment of poor copper matte, etc. Even now, with a basic lining and the addition of siliceous ores of value to the charge, a certain amount of success has been attained in this direction, but this is only an earnest of what may ultimately be reached.

"(d) The roasting of cupriferous pyritic ores in cast-iron vessels with a blast and additions of silica or lime.

"(e) The utilization of the sulphur dioxide from the poor gases from calcining and roasting plants for the manufacture of sulphuric acid by a 'contact' process.

"(f) Lastly, but by no means least, the electric smelting of copper ores where water power for generating electricity can be obtained at small cost. This process at present, however, has not passed out of the experimental stage.

"I have purposely confined my attention to furnace processes only, as the increased production of copper has been almost solely due to them. In future, however, electrolysis may be expected to play an important part, not only in the refining but also in the extraction of the metal from ores or mattes."

Metallurgical Papers Read in April.

Desulphurizing Copper Ores.

The April meeting of the Institution of Mining and Metallurgy had four papers presented for discussion. The first, by Dr. F. H. Hatch, described "A Visit to the Gold Fields of Orenburg, Russia," and dealt with the geological features of this district, together with the primitive methods in vogue. Mr. T. C. Cloud next communicated a description of "The McMurty-Rogers Process for Desulphurizing Copper Ores and Matte." The following extracts summarize the chief features of this process.

The converters used for burning the ore which have been installed at the Wallaroo Works, are cast iron pots mounted on trunnions and inverted by means of a worm and wheel, the inside diameter being 8 feet 8 inches by 4 feet 6 inches deep, the false bottom slightly convex and placed about 10 inches from the lowest part of the converter; it is perforated all over with $\frac{5}{8}$-inch holes. Originally these false bottoms were made of cast iron, but it was found better to use wrought iron plates strengthened with angle-irons underneath, these bottoms being held in position by a bolt passing through the center of the pot.

The *modus operandi* consists in first covering the false bottom with pieces of a previously burnt charge broken to from 3 to 4 inch size, then lighting a small fire in the middle of the pot on the top of this burnt material, using a light blast to urge on the fire, then charging the ore on top of this fire till the pot is about half full; after increasing the blast, and when the ore becomes more or less red in several places, the balance of the charge is added till the pit is full.

When the ring of fire has reached about one-third to half the diameter of the pot the ore is charged in on top, the first being put on with a shovel so as not to scatter the fire too much, but after a layer has covered the whole of the bottom the ore is then fed in by an elevator from the feed bins below, being spread by a man over the surface in such a way that when the pot is half full the ore is piled up more at the sides than in the middle, presenting a concave surface; the reason for this being that the ore has a tendency to make for the sides rather than up through the middle.

For some time coal was used, or a mixture of coal and fine coke, but sawdust was found to answer better, as the fire was not so hot.

When the pot is about half full and the charge distributed as stated, a number of holes are pricked near the center a slight distance down into the charge with a $\frac{1}{2}$-inch rod; the object of this being to give more or less free vents for the uncombined sulphur and sulphur dioxide to escape and so quicken the burning. These holes must be closed in before the ore burns through, otherwise blow holes would be formed; the man in charge soon learns to tell when the ore is getting near the top of any hole by the color of the smoke given off.

During the spreading of the charge the blast is usually turned off to enable the men to work comfortably, and after the holes have been pricked half blast is given for about an hour, being then increased to full pressure.

The full pressure of the blast used is 13 ounces, but it can be largely increased if necessary, over 20 ounces has been used, which latter pressure quickens the time of burning. The

volume of air used per minute at this pressure for each pot is about 1,000 cubic feet.

Each pot has to be covered by a hood in order to take off the fumes, a connection being made from the hood to a flue, or a large pipe taken out from the top of the hood through the roof of the shed. When the evolution of sulphur dioxide slackens and the charge has become red-hot throughout, the blast is turned off, the blast pipe disconnected and the converter inverted.

The elimination of sulphur is as good as is obtained by most calcining processes for copper ores, and if the sintered product were smelted alone, without the addition of some uncalcined ore, the regulus produced would be too high for good work.

The result of a sample from a large pile waiting for blast furnace treatment gave 5.65 per cent of sulphur; other results have given under 5 per cent of sulphur from raw ore containing about 20 per cent of sulphur and 10 and 12 per cent of copper.

The first experiments were made during 1904, and at the present time the plant which has been installed at Wallaroo is treating from 400 to 500 tons of ore a week.

Regulus or Mattes.—In treating these products the addition of some silicious material is necessary in order to take up the iron contained and form ferrous silicate; the proportions to be used are, preferably, from 15 to 25 per cent, but these may vary considerably. The silica may consist of such materials as coarse sand, jigged tailings, silicious carbonate ore, silicious oxide ore, and even silicious sulphide ore, such as dressed ore from buddles and Wilfley tables, has been used. The regulus should be crushed to pass a screen with meshes of from ½ to ¾ inch square; with soft mattes the larger screen should be used, but with hard low-grade mattes it is better to take the ½-inch size.

The starting of a regulus charge does not need as large a fire as in the case of ore, and very good results were obtained by using the lead kettles previously mentioned for this work, starting the fire with a little wood and sawdust on the top of the rough pieces of burnt material; the pots which are in use for the burning of rich regulus or "regule," to be subsequently described, were also found to give very good results in matte burning, as the product, being smaller, was easier to break up than the large cakes obtained from the lead kettles.

The blast used must not be too high, 6 to 8 ounces being enough at first, as the lower layer next to the fire is apt to run up to too high a temperature if a greater pressure is maintained at starting; the pressure can, however, be increased towards the end to the same extent as with the ore.

"White Metal" or "Regule."—The most satisfactory results obtained were with "metal" assaying from 78 to 80 per cent of copper, that grade known as "spongy regule" being the best owing to its porous nature.

By using the converter process for this operation the same end is obtained as far as the subsequent refining is concerned, but the troubles in the calcining are largely overcome and a more suitable product obtained for charging into the refining furnaces, and being in a lump form less loss from dusting.

Against this more slag is produced than is the case with the Nicholls and James process, but the elimination of the impurities is decidedly better than is obtained by treating "regule" by either the ordinary Welsh roasting process or the Nicholls and James process; this latter fact is of great importance where the better classes of copper are required, as, for instance, "Best Selected."

The final product obtained consists essentially of porous metallic copper mixed with oxide sulphate, and some unchanged regule, and for some time the main trouble was to break up the mass; this, however, was overcome by using a heavy iron ball weighing about 16 cwt., which was hoisted up by a steam winch 20 feet high, and allowed to drop on the sintered regule product; a few blows generally served to divide it into several pieces, which could be further reduced if necessary by the use of a sledge hammer and gad.

The third paper of the evening was that by Mr. G. T. Holloway, describing some "Laboratory Crucible and Muffle Furnaces," which had stood the test of nearly six years' uninterrupted use. Lack of space prevents my summarizing this paper.

The same cursory dismissal must be accorded to an interesting paper on "The Ironstone of Cleveland," by Mr. Arthur E. Pratt, which deals with this ore from the mines to the completion of its calcining in the kilns.

Market Prices During May.

In the chemical trade the following closing prices have to be chronicled: Copper sulphate, £33.10 per ton; ammonia sulphate, £11.17.6 per ton; potassium carbonate, £19 per ton (a further decline of 10s. 6d.), Montreal potash (in store, Liverpool), £40 per ton. Shellac is unchanged at £10.19.

In the metal market, copper, after advancing from £104 to £106.10 on May 1, receded steadily to £101.10 on May 8, and remained in this neighborhood until May 24, when it fell abruptly to £98.5 on May 28, rallying next day to £99.12.6, and closing on May 1 at £101. Tin stood at £195.15 on May 1, fell to £192 on May 3, recovered to £193 by May 13, and receded to £189.5 by May 15. An upward spurt of £192 on May 24 was followed by an abrupt decline to £187 on May 28, recovering to £190 on May 31. English lead has been steady, closing at £20.10. Antimony is easier at £67 to £70 per ton, owing to supplies from new sources which have relieved the scarcity of a few months ago. Platinum is easier at 110s. per ounce; thanks, also, to new sources of supply.

The rise in iron prices was well maintained until May 14, by which date Cleveland pig iron stood at 62s. 8d., and hematite at 81s. 10d. Irregular prices and a downward tendency resulted in a fall in Cleveland pig iron to 59s. 6d. on May 26, with a subsequent recovery to 61s. 10d. Hematite fell to 78s. on May 26, and recovered to 78s. 6d. on May 30.

London, June 5, 1907.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Low-Carbon Ferro-Alloys.—E. F. Price, 852,347, April 30, 1907. Application filed April 14, 1905.

The object is the production of low-carbon ferro-chromium, ferro-manganese, ferro-titanium, ferro-vanadium, etc., by the use of ferro-silicon as reducing agent. The first step of the process is therefore to produce ferro-silicon high in silicon and low in carbon by electrically smelting a charge of silica, iron ore or iron and carbon. This is done in furnace 1 of Fig. 1, the walls 2 of which consist of siloxicon, carborundum or carbon, while the hearth 3 is made of carbon. The furnace is surrounded by a metal casing 4 with an electric terminal 5. The depending carbon rod 6 constitutes the other electrode; 7 is the tap hole for slag and 8 is the tap hole for metal. The charge consists of finely ground silica, iron ore and coke, the silica and carbon being used in relatively large amounts. The molten ferro-silicon collects in the bottom of the furnace and is run through the tap hole 8 into the reduction furnace 9, which is lined with chromite or magnesia and also surrounded by a metal casing 11.

When ferro-silicon has been tapped into this furnace so as to provide the molten layer 16, arcs are established between the electrodes 14, 15 and this body of ferro-silicon, and the charge 17 containing the ore to be reduced (for example, a mixture of chromite with a basic flux such as lime) is fed into the furnace. The silicon in the molten silicide effects the reduction of the

chromite and is converted into silica, which combines with the lime to produce a fusible slag. The reduced chromium and iron alloy with the residual iron of the silicide and the slag accumulates upon the molten alloy as a floating layer 18. When reaction is finished, sufficient chromite being present to insure the oxidation of substantially all of the silicon, the slag and alloy are withdrawn through the tap holes 12, 13. More of the ferro-silicon is then tapped from the furnace 1, percolating through the hot unreduced charge in the furnace 9. The second stage of the process may be conducted in a continuous manner by retaining a pool of metal in the furnace 9, maintaining the arcs, and supplying the charge and molten ferro-silicon and withdrawing the slag and ferro-alloy as required.

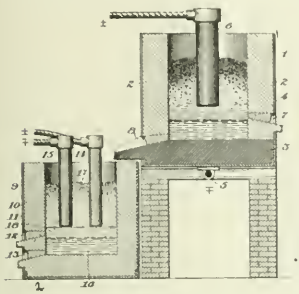


FIG. 1.—ELECTRIC FURNACE FOR FERRO-ALLOYS.

Electric Steel Furnace.—P. L. T. Héroult, 12,658, June 4, 1907. Application filed March 3, 1903. Assigned to Société Electro Metallurgique Française.

This patent refers to Dr. Héroult's well-known steel furnace, which may also be used for the production of soft metals, such as chromium, manganese and generally substances which tend to combine with carbon. There are two vertical electrodes passing through the top of the furnace yielding two separate arcs in series, each arc being formed between the end of one electrode and the slag on top of the fused bath. In order to insure the distinct formation of these two arcs two accessory circuits are arranged, connecting outside the furnace each of the two electrodes to the fused material, and in each of these circuits there is introduced in shunt a voltmeter, the indications of which serve to constantly verify and regulate the position of both electrodes and to determine whether or not the furnace is operating properly. (See our Vol. I., page 287, Fig. 1). Thus either by hand or by automatic mechanism operated by the two shunt currents each electrode can be raised or lowered to determine the arc, as desired. "When the arrangement is applied to the manufacture of steel or melted iron, there is directly obtained in the crucible metal decarburized by the slag, and the reducing gases in passing through the soft ore between the electrodes so act that the ore is partly reduced before undergoing electrical fusion. Cast iron can also be decarbureted or dephosphorated by the use of reagents according to the Thomas process." When the furnace is used for the production of metals "the slag is mostly imperfectly reduced mineral matter, or if the furnace be used to obtain stability of composition of mixtures of fine steel with other elements—such as chromium, nickel, tungsten, etc., the slag is composed chiefly of reagents designed to act on the bath of metal—such as lime, dolomite or oxide of iron liquified by the addition of silica—or it may be substantially neutral, such as a fusible silicate, which has no chemical action on the bath." The voltmeter terminal which communicates with the material in the crucible is a rod of the same metal as that being produced in the crucible and is built into or passes through the refractory wall of the crucible into the material within the same. When the rod melts the space or hole which it leaves in the wall is filled with molten conducting material the extent of fusion of which is limited by the proximity of the cold exterior wall. The current carried by this terminal is only a few milli-amperes.

Reduction of Iron Ore.—H. W. Lash, 856,351, June 11, 1907. Application filed Oct. 13, 1905.

The inventor treats a mixture of finely divided iron oxide (such as magnetic concentrates) with finely divided cast or pig iron and finely divided carbon (ground coke) and a flux. The addition of some sawdust is advantageous. The metallic portion of the charge may be shotted or granulated cast or pig iron, or finely divided cast iron obtained from any source. It is, however, to be noted that this iron must be of the quality commonly designated as cast, or pig iron, as distinguished from the ordinary run of scrap, wrought iron or steel, since it is important that it contain a high percentage of metalloids or easily oxidizable metals, such as manganese, capable of uniting with the oxygen of the ore. At the temperature available in the electric furnace the sawdust or readily combustible material, if present, disappears as such, leaving the mass to a certain extent porous. Upon the continued application of heat the metalloids and easily oxidizable metals contained in the cast iron and a portion of the carbon of the carbonaceous additions unite with the oxygen of the oxides present, thus reducing the iron oxides to metallic condition. The inventor states that he has obtained a recovery of 98.1 per cent of the iron with a charge made up of 16 parts by weight of iron ore, 16 cast iron, 2 carbon, 0.5 limestone, 0.5 fluorspar, 0.5 sawdust (total 35.5). He states that he obtained a recovery of 100 per cent of the iron with a charge made up of 18 parts by weight of iron ore, 7 cast iron, 2 carbon, 0.25 limestone, 0.25 fluorspar, 0.5 sawdust (total 28).

Cooling Electric Furnace Electrodes.—F. M. Becket, 855,441, June 4, 1907. Application filed January 30, 1906. Assigned to Electro Metallurgical Co.

The oxidation and destruction of carbon or graphite electrodes is prevented by artificially cooling them by means of water-jackets, as shown in Fig. 2. The two vertical openings 3 in the roof of the furnace contain the cooling jackets 4 of iron, which in turn receive the electrodes 5, 6. To the upper end of each jacket are connected pipes 7, 8 carried by the bracket 9 which is adjustably mounted on a vertical rod 10. The pipes 7, 8 serve both as a means of adjustably supporting the jackets 4 independently of the furnace roof and electrodes and for the supply and discharge of cooling water.

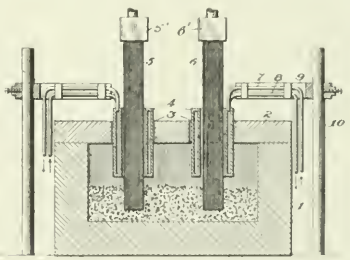


FIG. 2.—COOLING JACKETS FOR ELECTRODES.

Electrolytic Processes

Calcium-Zinc Alloy by Electrolysis.—F. von Kügelgen and G. O. Seward, 856,075, June 11, 1907. Application filed March 30, 1905.

Molten calcium chloride $CaCl_2$ is electrolyzed with a cathode of molten zinc at the bottom of the vessel. The calcium set free at the cathode alloys with the zinc. Calcium and zinc alloy in almost any proportion and all such alloys except those containing very little zinc are heavy enough to remain at the bottom of the cell, where the alloy is unattacked by the chlorine which is liberated at the carbon anode in the top of the vessel. The vessel may be of cast iron, and in this case the molten zinc cathode may be connected through the bottom of the iron vessel with the negative terminal. In this case no portion of the walls of the iron vessel should act as cathode.

loss may be prevented by water jacketing the walls of the vessel so as to produce a solid layer of calcium chloride which protects the iron walls. The calcium-zinc alloys are stated to be advantageous for use as reducing agents for which purpose the zinc is not disadvantageous. Metallic calcium is a very active reducing agent, but is expensive and very difficult to make. Calcium-zinc alloys are easily made. "The alloys if containing even as much as 10 per cent zinc are brittle and easily powdered. These alloys promise to have a wide application as reducing agents in place of aluminium or pure calcium."

Extracting Potash from Feldspath.—A. S. Cushman, 851,922, April 30, 1907. Application filed Jan. 14, 1907.

The object is to extract potash, soda and other soluble bases from ground rocks. Feldspathic or other potash-bearing rock is ground to fine powder, slimed with water and placed inside of a wooden porous cup which is placed in a larger vessel filled with water. Electrodes are inserted in the inner and outer vessel the electrode in the inner vessel being connected with the positive pole and that in the outer vessel with the negative pole. When current is passed through the cell the potash soda and other soluble bases are set free and pass through the wooden partition, so that the water in the outer vessel becomes alkaline. In order to accelerate the reaction which is otherwise very slow two methods may be used: (*a*) By a suitable grinding or churning arrangement the slime in the inner chamber can be kept in a continual agitation, which causes the necessary reactions to go on more rapidly. (*b*) If a small quantity of hydrofluoric acid is added to the slime a very great acceleration in the rate of decomposition and extraction is obtained, and it is possible in a reasonably short time to make a complete extraction of all the potash contained in a feldspathic rock. If instead of caustic potash it is desired to make various salts of potash such as are in ordinary use for fertilizers and other purposes, *i. e.*, nitrate, sulphate, chloride and phosphate, the corresponding acids, *i. e.*, nitric, sulphuric, hydrochloric and phosphoric, are fed in a dilute form into the outer chamber fast enough to neutralizze the caustic alkali as it forms. By varying the amount of acid added the resistance of the cell can be controlled and the decomposition of the rock carried on under the best and most economic conditions. "This application is made under the act of March 3, 1883, Chapter 143 (22 Stat., 625), and the invention herein described and claimed may be used by the Government of the United States or any of its officers or employees in the prosecution of work for the United States, or by any person in the United States without the payment of any royalty thereon."

Removing Scale from Iron.—C. J. Reed, 855,067, June 4, 1907. Application filed June 18, 1906.

In the present method (see also page 220 of our June issue) the iron sheets, rods or wire from which the oxide scale is to be removed are made cathode in a strong sulphuric acid solution. The result is the reduction of the scale to a lower state of oxidation and its electrolytic solution with the production of ferrous sulphate. An insoluble anode is employed and sulphur or an oxidizable sulphur compound is supplied to the electrolyte, serving by its oxidation to both depolarize the anode and replenish the acid in solution. The following specific instructions as to carrying out the process are given. The electrolyte consists of an aqueous solution of sulphuric acid having a specific gravity of about 1.20 equivalent to an acid content of 27.1 per cent. The anode may be of lead and the current density at the cathode from 40 to 70 amps. per square foot. The electrolyte is preferably maintained at a temperature of about 60° C. Free sulphur or an oxidizable sulphur-bearing compound, such as a super-sulphide of a non-alkali metal, specifically pyrite, marcasite or pyrrhotite, is supplied to or maintained at or near the anode, and the sulphur is oxidized to trioxide at a rate corresponding to the reduction and solution of the scale on the cathode, thus continuously replenishing the electrolyte. A diaphragm cell may be employed to retain in proximity to the anode any sulphur dioxide resulting whereby it is finally oxidized to trioxide and prevented from interfering with the cathodic reduction. The production of sulphuric acid corresponds to the rate of its consumption by the formation of ferrous sulphate, the electrolyte thus being maintained at the proper concentration. In the case of a diaphragm cell, the concentration of the acid in the catholyte is maintained by diffusion and cataphoresis from the anolyte. As the amount of iron sulphate in solution approaches saturation the electrolyte or catholyte is transferred to a shallow pan and allowed to cool. It is preferable to reduce its temperature to about 0° C. by the use of a suitable refrigerant. The iron sulphate crystallizes out and the residual solution is returned to the electrolytic cell, no evaporation or further treatment being required to fit it for continued use as an electrolyte.

Electrolytic Tank.—J. F. Miller, 856,277, June 11, 1907. Application filed Feb. 6, 1906.

Details of construction of a tank or vessel for electrolytic work, especially for electrolytic refining. The chief features are indicated in the claim, which reads as follows: "A tank for electrolytic work comprising side walls built up of a plurality of longitudinal sections placed edge to edge and formed with registering vertical openings; tie rods passing through said openings; a bottom composed of longitudinal sections between the side walls and formed with aligning transverse openings; tie rods extending through said openings and projecting through the side walls; end walls located between said sides and abutting the same, and composed of transverse sections having vertical aligning openings and horizontal openings; a U-shaped stay-iron at each end of the tank; horizontal tie rods extending through the horizontal openings in the end sections, the ends of the side walls and the vertical portions of the stay-irons, and vertical tie rods extending through the vertical openings in the end sections, the bottom and the horizontal portions of the stay-irons."

Purifying Hydrocarbon Oils.—G. L. Neiburg, 856,361, June 11, 1907. Application filed May 25, 1906.

In a kerosene can, that end of the spout which is joined to the can is in communication with a tube with perforated walls and constructed of electropositive and electronegative metals so as to represent galvanic couples. When kerosene is to be poured out of the can the kerosene must first enter this tube through the perforated walls in order to get into the spout. In passing through the perforated walls it is sub-divided in a great many small streams and is simultaneously subjected to electrolytic action by the numerous galvanic couples. The effect is said to be the decomposition of any sulphuric acid, etc., contained in the kerosene, while simultaneously the perforated walls act as a filter and prevent any suspension from passing out of the can.

Electric Discharge.

Ozonizer.—H. N. Potter, 854,965, May 28, 1907. Application filed Jan. 6, 1904. (Assigned to George Westinghouse).

When an electric current is passed through a tube, made of a material which is pervious to ultraviolet rays (like silica), ozone is developed in large quantities. If, therefore, the tube of silica is provided with electrodes inside the tube, one of the electrodes being of some volatilizable material such as mercury and the other of iron or other solid material and an electric current is caused to pass through the space between the electrodes, ozone is developed in large quantities in the air outside of and about the tube. The inventor proposes to enclose such a tube within another tube which is impervious to ultraviolet rays; for instance, ordinary glass. If air is then passed from one end to the other end through the space between the outer and inner tube it is ozonized, and the ozone may be collected. Arrangements may be made so as to force the air to pass through a zig-zag or tortuous bath between the silica and glass tubes, whereby a higher degree of ozonization is procured.

SYNOPSIS OF PERIODICAL LITERATURE

A Summary of Articles Appearing in American and Foreign Periodicals

IRON AND STEEL

Producer Gas. At the Spring meeting of the Verein deutscher Eisenhüttenleute, in Dusseldorf May 12, J. Korting delivered a remarkable lecture upon "Gas Producers and Their Use in the Iron Industry," which is reproduced in full in *Stahl und Eisen*, of May 15, pages 685-713. Concerning the distillation of the fuel used in the producers, if fuels are distilled at a high temperature there result strongly illuminating gas and fluid tars; when the distillation takes place at a low temperature, as in a producer, the quantity of hydrocarbons given off is larger, the illuminating gases and hydrogen smaller, and the tar is viscous and pitchy—in the case of lignite and turf even paraffin may be evolved. The solid carbon is then gasified by the action of the producer proper. For complete production of CO gas the bed of fuel must be of sufficient thickness; for coke in pieces 3 x 2 centimeters, 0.75 meter, 3 x 5 c. m., 1.15 meter, 5 x 7 c. m. 1.8 meter; for anthracite 1 x 2 c. m., 0.55 meter is sufficient depth; with large lumps of anthracite 1.5 to 2 meters thickness is necessary. Using bituminous coals it is recommended to work the producer with a warm top, thus distilling the coal at a somewhat high temperature, and so decreasing the amount of heavy tar in the gas, and consequent loss of heating power by its deposition in the conduits.

Using steam with air, the gas is enriched in hydrogen, but, at the same time, always contains more CO^2; it should not exceed 3 to 4 per cent in a well-conducted producer. One kilogram, or steam to 1 kg. of carbon burned is the limiting quantity of steam which can be used and properly decomposed. Methane, CH^4, is usually present, in quantities up to 3 per cent. Ethelyne (C^2H^4) and other heavy hydrocarbons are usually not present in more than traces, and then only when the coal gets distilled in the producer at a high temperature. If the products of distillation are forced to pass through the incandescent fuel by the hopper-like arrangement of feed, the tar is split up, increasing the CO and H^2 content of the gas and decreasing its CO^2. Free oxygen is seldom present in the gas; nitrogen varies from 60 per cent in dry running to about 50 per cent using steam. The calorific power of the gas varies from 900 to 1,100 Calories per cubic meter for simple gas, to 1,100 to 1,400 Calories for mixed gas. The gas possesses from 70 to 90 per cent of the calorific power of the coal from which it is made.

Korting next gives fifty-five analyses of producer practice, giving for each, in most cases, composition of the fuel, gas, calorific power of each, amount gasified per hour, temperature of gas combustible in the ashes, useful effect of the producer. The fuel used contains up to 26 per cent ash, in some cases 30 up to 45 per cent water, calorific power 2,750 up to 6,780, gas up to 16 per cent CO^2, 11 to 31.5 CO, 0.2 to 4.05 CH^4, 3.0 to 19.6 H^2, 0 to 1.5 O^2, 42 to 61 N^2, calorific powers 900 to 1,542 combustible in coal 0 to 35 per cent, useful effect 56 to 81.9 per cent. The lecturer concluded with a description of all the various types of producers, old and new, with critical remarks on their weak and strong points. His figures on the efficiency of the Korting steam-air blower are instructive; with 8 inches pheres steam pressure, 25 grams of steam will deliver 1 cubic meter of air against 50 m. m. water-gauge pressure, 37 grams against 100 m. m. pressure, 55 grams against 200 m. m. and 74 grams against 300 m. m. water pressure.

Gas Volumes. The determination of what volume of hot gas are coming from a furnace, or being used in a boiler or gas engine, is an important matter which has not yet received a fraction of the attention which it deserves. Engineer L. Seach of Bochum, discusses in *Stahl und Eisen* for March the application of the Pitot tube to such purposes in a rather but very convincing manner. The tube used has a flaring end to measure velocity head, and a similar end turned away from the current to measure static pressure. Since the shape of the latter causes a suction, this is corrected by calibrating the instrument in a current of air whose velocity is measured by an anemometer, and the error caused by the suction is assumed a constant proportion of the velocity head for all velocities. This method of correction is only approximate, however, and does not solve satisfactorily one of the chief defects of the Pitot tube. A registering apparatus devised by Paul de Bruyn, of Dusseldorf, is described, which records on a diagram the variations in velocity for a day or a week. Charts are given showing the variations in velocity in a down-corner from a blast furnace, and gas pipe from a coke oven, and the applicability of the apparatus to control the gas consumption of gas engines.

Hot Blast Stoves.—Fritz W. Lurmann, in *Stahl und Eisen* for April 10, makes a plea for two improvements in hot blast stove practice. One is the use of refractory fillings which shall be at least as refractory as Seger cone No. 34, which is supposed to melt only at 1,870° C. Using such refractory brick the troubles of melting down the filling will be overcome, since the theoretical temperature of combustion of the gas lies between 1,425° and 1,880°, and is usually 60 to 100° less than this theoretical value, because of some excess air, about 10 per cent, being used for combustion. The other plea is for gas purified beyond the usual limit of 0.5 gram of dust per cubic meter. With this content of dust, particularly if it is of an alkaline nature or contains manganese oxide, the brickwork of the stove soon becomes slagged or fluxed, and the interior of steam boilers get a glassy or slag-like coating which is a very poor conductor of heat. In almost every case it will pay to purify the gases considerably beyond 0.5 gram of dust per cubic meter.

High-Speed Tool Steels.—In F. W. Taylor's address before the American Society of Mechanical Engineers the following classification of steels had been given: Carbon-chromium-tungsten; carbon-chromium-molybdenum; carbon-chromium-molybdenum-tungsten; carbon-tungsten-nickel. In a note from the author of the *Electrical Journal* of June it is pointed out that the investigations made by Mr. White and himself, and which included exhaustive tests on all of the above groups, showed the combination of carbon tungsten nickel to be unsuitable for high-speed tool steels, and, further, any combination in which nickel enters in or from which chromium has been omitted is equally unsuitable. The division of high-speed tool steels into the four classes given was a purely nominal one and was based upon the outcome of a series of analyses made in 1904-1905 of twenty-two brands of commercial steel, both American and foreign, one of these being found to contain the combination of carbon-tungsten-nickel, as stated. Subsequent trials of this steel under actual shop conditions proved it to be inferior to most of the other samples in the amount of work performed.

COPPER.

Alloys with Silver and Lead.—K. Friedrich and A. Leroux, at the Bergakademie, Freiberg, are still adding to their metallurgical investigations. In *Metallurgie* for May 22 they publish a new contribution of twenty-two pages, accompanied by forty-seven diagrams and thirty-four photomicrographs, dealing with the binary systems Cu — Ag and Cu — Pb and the ternary system Cu — Pb — Ag. They found in the system Cu — Ag two kinds of crystals, one consisting of nearly pure copper, the other a solid solution of copper in silver. The eutectic contains 28 per cent of copper, melts at 778°, and exists nearly up to pure copper on one side and down to 0 per cent silver on the other. In the system Ag — Pb the eutectic is at 3 per cent silver, melting at 300°, and found in the alloys nearly to pure silver and to pure lead. In the system Cu — Pb there are two kinds of crystals of the pure or nearly pure metals, with no eutectic and no compound. In the ternary system Cu — Pb —

Ag, the ternary eutectic lies at 0.5 per cent copper, 2.0 per cent silver and 97.5 per cent lead, at about 299°. On one side of this point are mixed crystals of silver and copper containing very little lead, on another side crystals of silver with considerable lead and copper, on the third side nearly pure lead.

Alloys with Phosphorus.—E. Heyn and O. Bauer (*Metallurgie*, April 22 and May 8) have made a study of the alloys of copper with up to 15 per cent phosphorus. The melting point falls uniformly at the rate of 30° for each 1 per cent of phosphorus up to 6.5 per cent, then falls sharply to a eutectic containing 8.27 per cent of phosphorus, melting at 707°. Above this content the melting point rises rapidly to 1,018° at 14 per cent, and stays then practically constant to 1,022° at 15 per cent. The very well-marked eutectic was in evidence by arrests in the cooling curve at 707° for all the alloys from 2.76 to 14 per cent phosphorus. The electrical potential of these alloys against copper in normal $CuSO^4$ solution was measured. There was no difference of potential at all, *i. e.*, the alloy behaved like pure copper, until at 14.1 per cent phosphorus, corresponding to the formula Cu^3P, the potential fell to — 0.020 volt, and at 15 per cent phosphorus to — 0.063 volt. The conclusions from these observations as well as the microscopic tests are that up to 14.1 per cent phosphorus the alloys consist of mixtures of copper and Cu^3P, that higher alloys consist of mixed crystals of Cu^3P and another compound, probably Cu^6P^2. The specific gravities of the alloys fall regularly from 8.92 down to 7.18 at 14.1 per cent phosphorus (Cu^4P), and then more rapidly to 6.79 at 15 per cent. As for hardness, the eutectic at 8.27 per cent phosphorus was as hard as soft iron (0.05 per cent carbon), the compound Cu^3P was nearly as hard as hardened 0.95 per cent carbon tool steel. Alloys with over 14.1 per cent phosphorus lose their excess of phosphorus at 1,100° C., and come down to the compound Cu^3P. To make phosphor copper up to 20 per cent, copper filings are mixed with red phosphorus and the mixture put into crucibles, covering with charcoal. By heating to 300-400° C., not over 700°, a sintered mass containing up to 20 per cent phosphorus is obtainable, which can be used for the deoxidation of bronzes.

Gold.

Cyanide Practice with the Butters Filter. Mr. E. S. Pettis, in *Mining and Scientific Press*, March 23, gives some data regarding the operation of the Butters filter at the Combination Mill, Goldfield, Nev. The plant in question contains two slime storage vats, two wash-water vats, the filter box and canvas frames, one acid box for washing the frames, one vacuum pump, one 4-inch centrifugal slime pump, one 2-inch centrifugal pump and the necessary valves and piping. The inside top measurements of the filter box are 9 feet 11¼ inches x 10 feet 2½ inches, the sides extending 5 feet 9½ inches above the cone. From the discharge gate to the top the distance is just 11 feet 7⅝ inches, the capacity is about 785 cubic feet when not containing the frames. The latter are 116⅜ inches x 56¼ inches, each having about 90 square feet of filtering surface. The frames are twenty-seven in number, namely, six sets of four and one of three. About 35 tons of slime are treated daily, forming a ¾-inch cake on the filters with a 22-inch vacuum. The washing is carried out with the same amount of vacuum for from 70 to 80 minutes with a weak solution of cyanide of 0.8 pound, about 10 tons of wash solution being used in that time. As the water is scarce in Southern Nevada, it cannot be used in the washing of the cakes, otherwise the time consumed would be about two-thirds of that required with the use of a cyanide solution. Less time would also be required for washing the cake if the slime could be agitated or heated in just twice as much solution as is used at present, thus necessitating less time of agitation. The time required for the various operations after the installation of the plant was as follows, the first figures referring to the minimum and the second to the maximum time required: Filling of box with pulp, 16-18 minutes; 22-inch vacuum, while forming ¾-inch cake, 19-22 minutes; employing box with 5-inch vacuum in cakes, 16-17 minutes; pumping in weak solution, 15-16 minutes; washing with weak solution, 15-inch vacuum, 40-50 minutes; pumping back weak solution, 15-16 minutes; filling with wash-water, 15-16 minutes; washing with wash-water, 22-inch vacuum, 30-50 minutes; sampling cake, 7-10 minutes; dropping cake with water, 12-14 minutes; running back surplus water, 8-10 minutes; sliming, 5-7 minutes; a total minimum time of 198, or maximum of 246 minutes. Five months later, with an increased amount of slime in the pulp and carbonate of lime formation noticeable on the filters, the time required was as follows: Filling, 18-20 minutes; vacuum, 22-25 minutes; emptying with 3-inch vacuum on cake, 17-20 minutes; pumping in wash, 16-18 minutes; washing with 22-inch vacuum, 70-80 minutes; sampling cake, 7-10 minutes; dropping cake, 14-15 minutes; running back water, 8-10 minutes; sliming, 5-7 minutes; total of 177 and 205 minutes, respectively. It was found that better results were obtained by giving only one wash. After the washing the cakes are dislodged from the frames by water forced from the inside. The formation of carbonate of lime on the filters is an essential obstacle which must be renewed. This cannot be accomplished by simply dipping the frames in a 2 per cent solution of hydrochloric acid, where any large amount of lime, from 7 to 20 pounds per ton, is used in the milling of the ore, but must be done by washing with the use of a vacuum or other means which forces the 2 per cent acid solution for 15 to 45 minutes through each cell of the cocoa matting. If the latter is done, the frames will only have to be cleaned once in three or four months, while the dipping would have to be done every three or four weeks. One man per shift operates the valves from a platform near the filter box, and he has plenty of time for other mill work. The author considers that as an improvement in mill work the Butters-Cassel process ranks with the tube mill.

Aluminium.

Progress in 1906.—In the *Engineering and Mining Journal*, of June 15, J. W. Richards reviews the progress in the use of aluminium in 1906. E. S. Sperry has studied the formation of pin-holes in aluminium castings. They are due to the metal absorbing gases while in the furnace and giving them out as it sets. To get absence of gas in the metal the top of the crucibles should project out of the fire and above the top of the furnace like a zinc melting pot. Overheating must in all cases be avoided. A. Brown recommends using chills at such parts of an aluminium casting as are ordinarily provided with risers. The latter are often a detriment to a fine casting, causing shrinkage cracks and being difficult to cut off. Pieces of sheet copper or brass, rather thick and flat, about 1/16 inch thick, may be used, being placed so as to cover the part of the casting which it is intended to chill into shape. They can thus be made to cause heavy portions of the casting to cool off as quickly as the lighter parts which are not chilled, and thus preserve the shape of the heavier parts, avoid unequal cooling and shrinkage strains. The proper heat for casting the aluminium is a very low red.

For electroplating upon aluminium, A. Giroux emphasizes the necessity of careful preliminary treatment. The articles are first cleaned in potassium cyanide solution until the greasy spots are loosened; then cleaned by brushing with powdered pumice until a clean surface is obtained. They are then to be well washed and dipped into caustic potash solution until gas bubbles are evolved, and are then immersed in cold water. They are then dipped into a solution containing 0.2 per cent of corrosive sublimate and 2 per cent of potassium cyanide. They are then dipped once into the caustic potash solution and placed at once in the plating bath. The plating must be done slowly and evenly, not at any time showing evolution of gas; only in this way can an adherent plating be obtained. (In connection with this subject the article by C. F. Burgess and Carl Hambuechen in our Vol. II., p. 85, contains useful, practical information on plating upon aluminium.)

Two new solders for aluminium are mentioned but it is stated that the one solder which has found most extended use in practice is that patented by Joseph Richards and containing 29 parts of tin, one of zinc, one of aluminum and one of phosphor tin. Reference is then made to the method of welding aluminium surfaces together and the progress which has been made by M. U. Schoop in this respect.

Concerning uses of aluminium it is said that aluminum is largely supplanting phosphide of copper as a deoxidizer in brass and bronze, in which it acts by reducing the oxides of copper, zinc or tin with which the metal may be contaminated. A small excess of aluminium does not injure the metal so much as a small excess of phosphor. Care must be taken, however, not to cast the alloy immediately after using the deoxidizer, since the alumina formed must be given an opportunity to rise out of the metal and enter the slag. With pure copper used for electrical purposes, silicon is found superior as a deoxidizer to aluminium, because the silica formed is less infusible, tends to unite with copper oxide to a fusible slag, and thus gets out of the melted metal quicker and more completely, leaving it with higher electric conductivity. Dr. Hans Goldschmidt the inventor of the aluminothermic process, has recently patented improvements in his method of obtaining fluid iron at high temperature for welding purposes. In place of aluminium as the sole reducing agent acting upon iron oxide, producing the difficult fusible alumina, he uses a granulated alloy of calcium and aluminium, or a mixture of these two metals in granular form. This alloy gives a very high thermal effect, higher even than aluminium alone, while the heat of formation of the aluminate of lime slag is also utilized, and the slag is much more fusible than alumina alone. Supposing the alloy of calcium and aluminium to contain 42.5 per cent of calcium, corresponding to $CaAl_2$, the reaction on Fe_2O_3 would probably be

$$5Fe_2O_3 + 3CaAl_2 + 3(FeO.\ CaO.\ Al_2O_3) + 7Fe.$$

In this reaction 70 per cent of the iron in the oxide used would be reduced to the metallic state, while the resulting slag would be very fluid, and 1.4 parts of fluid iron at high temperature would be obtained per one part of calcium-aluminium alloy used. References are then made to the metallic paint of silver-white color made of powdered aluminium. Various miscellaneous applications of aluminium are dealt with, and finally notes are given on quite a number of aluminium alloys.

Fuels.

Charcoal Ovens.—F. Juon, of Nadeshdinski, Urals, describes in *Stahl und Eisen* for May 22, the improved ovens of Wladykin and Bynewitzch. These ovens are furnished with step grates, burn charcoal fines, and by tortuous flues distribute the heating gas very uniformly, so that variations of temperature of not over 35° C. occur in different parts of the furnace. In ordinary kilns variations of 130° in different parts are common, causing great variations in the carbon content of the charcoal, whereas, in these ovens the variations in carbon content are not over 2 to 3 per cent, making a very uniform quality. The plant at Bogoslow has forty-eight of these ovens, and the following observations and tests were made upon them: Immediately on charging wood and closing the oven, water comes off, and this period lasts 1 to 2 days, with temperature seldom exceeding 200° C. Then yellow vapors are given off, which condense to a brown fluid, this period lasting two to three days. The gas then becomes gradually colorless and "dry"; at this time hydrocarbons and hydrogen begin to come off plentifully. This lasts 3 to 8 hours, and then the chimney is shut off by a flue, all openings carefully luted, and the oven left standing. The gases still coming off cause an excess of pressure in the kiln, and the oven is let cool under this pressure until the sides are nearly cold. The duration of this cooling depends largely on the weather, lasting six to ten days, making the whole campaign ten to fifteen days.

The products of combustion from the combustion of the fines on the grate averaged over a long period (dried before analysis):

	Per Cent.
CO^2	16.8
O^2	0.1
CO	6.7
H^2	1.8
CH^4	0.2
N^2 (difference)	74.4

The uncondensed gases from the oven at different periods were carefully analyzed, and from them, on the basis of nitrogen content, the products coming from the grate were deducted, giving the real gases distilled from the wood and not condensed the following compositions:

	Temp	CO^2	CO	H^2	CH^4
Beginning	< 170° C.	No uncondensable gas			
End of steam production	170-200°	68.3	29.6	trace	1.1
Beginning of first charring	200-300°	65.3	30.5	trace	3.9
Middle of first charring	300-370°	67.4	30.0	0.3	2.3
End of first charring	350-390°	43.4	26.7	2.8	26.2
Beginning of second period	390°	30.8	14.4	8.7	46.0
Middle of second period	150°	10.2	11.6	0.1	78.0
End of soaking period	60°	3.2	4.6	0.0	92.0

The cooling off period is characterized by absorption of CO, CO^2 and H^2 and great increase of hydrocarbons in the kiln. In this manner of working the charcoal contains 6 per cent higher carbon than when the oven is not sealed tight and put under its own self-generated pressure.

Miscellaneous.

Calcium.—In *L'Eclairage Electrique* of May 25, Jean Escard gives a brief review of various processes for producing metallic calcium, especially by electrolysis, and also refers to calcium alloys. Metallic calcium is believed to be especially useful in metallurgy for purifying fused metallic baths on account of its reducing properties. Calcium hydride (trade name hydrolyte) in contact with water gives off pure hydrogen gas. One kg. of calcium hydride sets free 1 cubic meter of hydrogen.

RECENT METALLURGICAL PATENTS

Iron and Steel.

Magnetic Manganese Steel.—Mr. R. A. Hadfield, of Sheffield, has recently patented (856,250, June 11, 1907) a composition of steel containing less than 1 per cent of carbon and from 10 to 40 per cent of manganese. This steel has certain distinct properties which are not found in high-manganese steels as heretofore made, due to the fact that formerly ferro-manganese has been used containing too high a percentage of carbon, say, from 6 to 9 per cent. If ferro manganese is used, however, as made in the electric furnace, with a low content of carbon say, from 2 to 3 per cent, and containing from 70 to 90 per cent of manganese, the resulting steel has very distinct properties. Owing to the comparatively low percentage of carbon in the manganese steel, the steel is rendered much less liable to fracture during the cooling, or heating and cooling treatment for toughening it, and such steel is distinguished by its relatively strong magnetic character. In making the steel the ferro manganese is added, preferably in a molten condition, to a base of molten decarbonized iron, such as that used in the production of acid steel, and from which practically the whole of the carbon, silicon and manganese have been eliminated in suitable manner, as, for instance, by the pneumatic or the open-hearth method.

Flux for Soldering Cast Iron.—Owing to the impurities of carbon, silicon, etc., cast iron has proven difficult to solder or braze without the employment of oxidizing fluxes. Certain of these now in use contain heavy metallic oxides which are

recommended to remove the impurities by selective oxidation and leave a sort of wrought iron surface to which the solder or spelter will adhere. According to Carleton Ellis (852,017, April 30) such fluxes require a high temperature to complete the operation. He has found that a lower temperature is quite sufficient if the flux contains, as an essential element, chemically pure and finely divided iron. Another element is anhydrous borax or other easily fusible, non-oxidizing anhydrous salt or compound. The action of a flux of this character, viz.: pure iron and anhydrous borax, is to remove the impurities from the cast iron surfaces to be joined, by a sort of impregnation. In other words, the chemically pure iron at a low red heat is most avidious for carbon, silica, etc., and absorbs them from the cast iron surfaces with great rapidity. Thereby the surfaces are purified and put into condition for uniting with the solder or spelter which is subsequently introduced. To produce the finely divided chemically pure iron, oxalate of iron is ignited in a current of hydrogen. "A suitable composition for general purposes may be obtained by mixing thoroughly the following: Fused borax (pulverized), 12 pounds; iron powder, C. P., 40 pounds; carbonate of potash, C. P., 9 pounds." A quantity of this mixture is worked up with water to a thick paste and is applied to the cold cast iron surfaces to be joined. The surfaces are then pressed into contact and are heated by a gas flame or otherwise. When the brazing temperature is reached the solder is run in together with copious additions of anhydrous borax until union is complete, when the object is carefully cooled and cleaned. During the stage of cooling the pieces of cast iron should be kept in immovable contact. "In this manner iron castings of every description may be easily and firmly joined."

Alloys.

Purifying and Alloying Metals.—In a patent of I. L. Roberts (845,819, March 5, 1907) a method is described "of varying the composition of a metallic alloy or mixture, which consists in treating the same in the molten state with a flux composed of fluorides and containing a compound of a metal less basic than the element to be removed from the alloy or mixture." The method may best be explained by some examples. Raw or crude copper frequently contains iron. To remove this the copper is melted and a flux consisting of a mixture of calcium and sodium fluorides with a sufficient quantity of copper fluoride is added and the whole agitated. The fluorine has a greater affinity for iron than for copper, hence the copper in the copper fluoride contained in the flux is released and the iron from the crude copper takes its place. Zinc, cadmium and any other metal for which fluorine has a stronger affinity than for copper, may be removed in the same way. A second example is the manufacture of nickel steel. By melting together cast iron with a flux of calcium and sodium fluorides containing an oxide of nickel, such substances in the iron as carbon, sulphur, phosphorus, arsenic, etc., will be oxidized by the oxygen from the nickel oxide and will be taken up by the flux while the metallic nickel thus freed will alloy with the iron. In the same way chromium may be substituted for other substances in the iron and chrome steel may be produced, etc. A third example is the removal of sodium from an aluminium-sodium alloy. By using a flux of calcium and sodium fluorides the fluorine in the aluminium fluoride will take up the sodium from the aluminium-sodium alloy, releasing the aluminium with which it was in combination. Or if fluoride of magnesium is used to remove the sodium the product will be an alloy of aluminium and magnesium, which is known under the name of magnalium.

Tin.

Detinning.—We have repeatedly referred in these columns to the important industry of recovering tin from "tin scrap." This scrap comes from the factories making tinned iron cans, etc., which are now used to such an enormous extent. The detinning industry is at present undergoing changes in two different directions. First, with respect to the material treated the scrap of the can factories, *i. e.*, quite a clean and pure raw material, iron covered with tin, was formerly exclusively used, while according to a patent recently noticed in this department, at least one plant, namely, the pioneer plant of the whole industry, that of Theodor Goldschmidt, in Essen, now also recovers tin from cans which have been in use. Here the raw material is exceedingly impure, but if success is attained the sphere of the process is immensely broadened. The second important change is the method of working. In the past the process of detinning has been electrolytic, while now detinning by means of chlorine is pushing to the front. To emphasize this change still more the electrolytic detinning process has always been treated as a secret process, not protected by patents and, of course, never adequately described in print. On the other hand, with respect to the new chlorine-detinning process there exist already quite a number of patents. Several important patents of Dr. Karl Goldschmidt have been discussed before in these columns. In the following we record four more patents granted to American inventors.

Messrs. F. von Kuegelen and G. O. Seward (851,946, April 30) refer to a former process patented by them, in which the scrap is placed in a vessel and dry chlorine is admitted thereto, attacking the tin and forming stannic chloride, which is condensed upon the walls of the vessel. The temperature must be carefully controlled. It must always be kept below the point at which iron-chloride is formed. If, however, to avoid this result the temperature is kept too low, the detinning is slow and not so complete as it should be. To prevent overheating the inventors formerly proposed to limit the amount of chlorine introduced and at the same time to cool the vessel externally. In the present patent they propose to obtain the same result by limiting the amount of tin scrap placed in the vessel. "It is impossible to lay down any definite limits of proportion for the successful practice of our invention, but with a chamber of 40 cubic feet capacity, a charge of 150 pounds of tin scrap has given successful results."

Another method is this: "Instead of limiting the amount of chlorine or amount of scrap used in a vessel of a given size, we use at once such a powerful current of chlorine that the same is present in great excess above the reactive proportion. Chlorine is now passed through in such a large volume that the current of cool gas flowing through the detinning tank exerts a cooling action on the contents."

A second patent of the same inventors (853,461, May 14) refers to the method of removing the stannic chloride formed from the vessel in which the process has been carried out. "After the reaction is complete and the tin in the tank has all been converted into stannic chloride which has been removed as much as possible by gravity from the bottom of the tank, we continue to pass dry chlorine through the tank, which now contains scrap free from metallic tin, but with a certain amount of stannic chloride adhering to it. Chlorine has the capacity of absorbing a great quantity of stannic chloride, and by availing of this property we thus get rid of the remainder of the stannic chloride so that it is taken up by the chlorine and passes out of the tank with it. The operation might be likened to the drying of a damp vessel by passing dry air through it."

Mr. Charles E. Acker (855,491, June 4) patents a "process of detinning which consists in subjecting compressed tin scrap to the action of a detinning reagent, and forcing the reagent into the interstices of the scrap by varying the pressure during the detinning." The detinning reagent may be an "elementary gas or gas mixture, for example, chlorine, bromine, or a mixture of either of these gases with other gases or air; a solution of an elementary gas in a liquid for example, chlorine in carbon tetrachloride or stannic chloride; or a gaseous or liquid compound, for example, a chlorine compound in which the chlorine is loosely bound, such as bromine chloride."

A second patent of the same inventor (856,753, June 11) relates to the treatment of the detinned iron and residues which remain after the tin-plate scrap has been subjected to

the action of chlorine, converting the tin into its chloride. The residual mass, on account of its numerous interstices, retains a considerable percentage of the tin salt. To recover it the detinned material is washed with an anhydrous liquid, which is a solvent for stannic chloride, specifically with carbon tetrachloride, or anhydrous petroleum. The wash liquid, containing the dissolved chloride and usually some chlorine, is then run off and may be used for the treatment of other residues. After it is drained off the portion adhering to the residue may be removed by a current of air by means of an exhaust pump. The mixed air and vapor is then passed through a solvent for the vapor, preferably a heavy mineral oil. "The detinned iron resulting from the treatment of scrap with chlorine is usually coated in part with a very thin film of ferric chloride. In order to remove this film and protect the surfaces from rusting upon exposure to the atmosphere, it is desirable to submerge the metal, either before or after removal from the detinning chamber, in a weak alkaline bath, for example, an aqueous solution of sodium hydroxide or carbonate."

Neutral Soldering Flux.—O. J. Lanigan (851,813, April 30, 1907) describes the composition of a neutral flux specially suitable for soldering the seams or caps of tin cans. The flux consists of equal proportions of glycerine and ammonium lactate. The flux, being neither acidulous nor alkaline, does not deleteriously affect canned fruit products.

Aluminium.

Alloy.—A. Chambaud (856,392, June 11, 1907) patents a new aluminium alloy for which very characteristic qualities are claimed. It consists of 99.020 per cent aluminium, 0.310 iron, 0.010 zinc, 0.041 magnesium and 0.610 copper. To manufacture this alloy about 20 per cent of the aluminium to be employed are first melted, and when the temperature has reached about 750° C. copper is added, and when the fusion of this last metal is complete zinc is added and afterward iron, and when the fusion of the mixture is complete the remaining 80 per cent of aluminium are added. Finally the magnesium is incorporated when the fluid mass is withdrawn from the fire. The alloy is of a white silvery color and has a density not exceeding 2.7. It is claimed to be very elastic, malleable and ductile and more tenacious than copper, to beat out, emboss, hammer, bend, wire draw and weld very easily. It can be worked without the use of special tools. It is said to have great tensile strength and not to be oxidizable in air or water. It is stated to be particularly useful in cases where it is exposed to the action of sea water. It is said not to be seriously attacked by any acid except hydrochloric acid.

A Proposed Society of Chemical Engineers.

A meeting of those chemists who were in favor of the establishment of a Society of Chemical Engineers, and who were in attendance at the American Society for Testing Materials, was held at the Hotel Chalfonte, Atlantic City, Friday, June 21, at 5 P. M. The meeting was called to order by Mr. Richard K. Meade. Dr. Charles F. McKenna was made chairman and Mr. William M. Booth, secretary.

Mr. Meade then stated that he had issued a call for the meeting because of the numerous requests which had been made that he should take the initiative in the organization of such a society. He further stated that he had been informed that a society of chemical engineers was in process of organization on the Pacific Coast, and he had been urged to make the movement a national one. Mr. Meade said he felt that such a society was really needed, and had sounded the profession by some fifty or more letters of inquiry to prominent technical chemists and engineers.

A large number of those approached replied, expressing their opinions quite freely, and for the most part were in favor of the organization of such a society to be known as the American Society of Chemical Engineers. Those in favor of the organization thought it should have a high standard of admission, somewhat along the requirements of the American Society of Civil Engineers, and that it would prove of great benefit to all qualified technical chemists. For the members of the new society it was suggested that it might, by the appointment of committees, solve many problems of engineering chemistry, widen the field of applied chemistry to the point where chemical plants will be designed as far as the chemical features go by chemical engineers; further the interests of the consulting chemist by the discouragement of unprofessional methods, and if possible cause the elimination of all incompetent and dishonest followers; the direction of the education of technical chemists along lines most likely to be of benefit to the industries of the country, for the commingling of the ideas of professional men with those of teachers of applied chemistry; the unification of the methods of technical analysis by committees which should represent both manufacturers and users; the encouragement of patent legislation which will give the greatest security to the inventor of chemical processes and appliances for carrying them out, etc.

The discussion naturally turned first to what the term "chemical engineer" really means. This was answered provisionally by Mr. Booth as follows: Chemists or mechanical engineers who design and construct plants of a nature requiring a thorough fundamental knowledge of applied chemistry may be termed chemical engineers.

The various difficulties in the way of forming a society of chemical engineers were gone into at great length. Those who took part in the discussion were Prof. H. B. Talbot, Mr. H. E. Diller, Mr. F. C. Holton, Prof. J. C. Olsen, Prof. William H. Walker, Dr. J. E. Stokes, Mr. Andrew Robertson, Mr. A. D. Little and Mr. Richard K. Meade. Finally, it was decided upon motion of Prof. Olsen to appoint a committee of five men with power to consider the advisability of organizing a society of chemical engineers, that this committee correspond with men likely to be interested, and, further, that the conditions of membership of such a society be formulated. Dr. McKenna named the following: Prof. J. C. Olsen, Mr. A. D. Little, Mr. Richard K. Meade, Prof. Wm. H. Walker, Mr. William M. Booth. Mr. Olsen offered a motion that Dr. McKenna act as chairman of this committee, thus increasing the number to six. This motion was carried.

It is expected that a report will be made sometime during the summer.

Repairing with Thermit.

The chief difficulty in doing general repair work by the thermit process has been to design the proper pattern for the mold, and to determine the correct amount of thermit to be used. This has usually necessitated dividing the work between the foundry and the forge shop, and has often been the cause of delay and trouble.

The Goldschmidt Thermit Co. has now developed a system which obviates these difficulties and permits of the entire work being done without the aid of the pattern maker.

By this system yellow wax is used as a pattern or matrix for the casting, and the parts to be welded are simply laid together, and this yellow wax pattern shaped about them. After this is done the mold box is placed in position, and molding sand (consisting of a mixture of fire clay and sand) tamped around the matrix in the usual manner, except that a small hole is left in the lowest part of the mold. The pattern for gate and riser may be easily constructed of wood in the usual manner. After the mold box is completely filled the gate and riser patterns are withdrawn, and a torch applied through the riser to the wax matrix, which will melt and run out through the opening at the bottom. The heating should be continued until the metal is

red hot and the mold thoroughly dry, after which the opening at the bottom should be closed with a sand core. The weight of wax should be multiplied by 32, to give the correct weight of thermit required for the weld. For welds requiring over 50 pounds of thermit 15 per cent of punchings should be used, for smaller welds 10 per cent of punchings. The pouring is performed in the regular way.

This system of wax patterns enables repairs to be made much more quickly, cheaply and accurately than heretofore, and is applicable to all kinds of thermit welds.

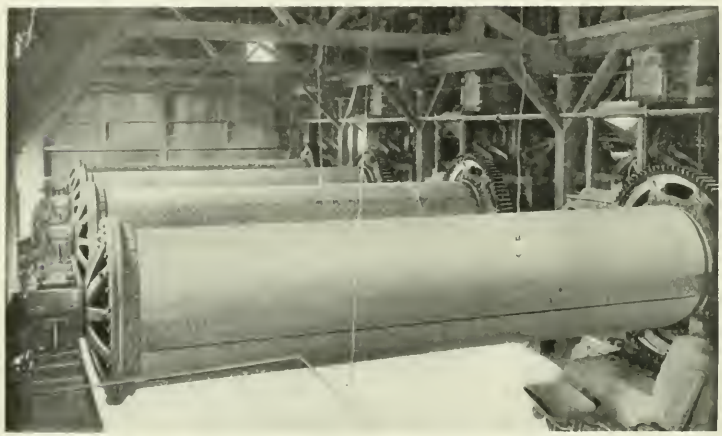


FIG. 1.—SET OF FOUR TUBE MILLS.

For the special problem of welding locomotive frames the Goldschmidt Thermit Co. has recently perfected a mold made of fire-brick which can be obtained in standard sizes ready for use; this eliminates much of the preliminary work which was formerly necessary and allows of the repair being made quickly and accurately. The work can now be done in division shops and round-houses, as all tools necessary are part of equipment of such shops. Further details may be found in a pamphlet recently issued by the Goldschmidt Thermit Co. on fire-brick molds for welding locomotive frames by the thermit process.

Large Tube Mills in the Cyanide Process.

In view of the interest that is now being taken in the cyanidation of gold and silver ores, where the question of a fine pulverizer or slimer is one of vast importance, it might be interesting to consider some of the features of one of the largest tube-mill installations made in connection with this class of work.

The United States Reduction & Refining Co. purchased in the early part of 1906 one of the usual style trunnion tube mills, 5 feet diameter by 14 feet long, for the purpose of making experiments on fine grinding and studying the obtainable extraction on the tailings accumulated at their mills at Colorado City.

The machine installed had the usual trunnion type feed equipped with stuffing box, etc., had manholes in the shell, so that the mill could be relined, fresh pebbles put in when necessary, and all the usual troubles were experienced, to wit: There was a constant tinkering with the feed on account of leakage and the lining kept on falling out around the manhole opening. Notwithstanding these facts the users became convinced that the process would be advantageous to them so that they took up the matter of a larger plant.

They had presented for their consideration the Abbé tube mill, and although they were first skeptical in reference to the advantages of the "ideal" spiral feed and discharge, with which this tube mill is equipped (described and illustrated in our Vol. III., p. 42), they decided to try an experiment on their own account. A rough spiral of pipe was built and attached to the trunnion of the tube mill which they had, with the result that this proved to be entirely satisfactory to them in every respect, so that they placed their order for eight Abbé tube mills, 5 feet diameter by 23 feet long, the order being placed at several thousand dollars higher than the nearest competitor's figure.

These machines are without doubt the heaviest ever constructed for mining work, the iron and steel work alone weighing 38,000 pounds for each mill. This is without silex lining or pebbles.

In view of the fact that the United States Reduction & Refining Co. had operated another make of tube mill at their plant, they installed for each two machines a separate 150-hp. motor, as they did not take into consideration that with the use of the spiral feed they would gain the additional advantage of reducing the horsepower on account of being able to load the mills over the center with pebbles.

Recent tests made by Mr. Fox, superintendent of the plant, show that each mill only requires 46 hp., or somewhat more than one-half what was allowed to operate them. The trunnion bearings of the mills were made very large and were equipped with water-cooling boxes. The material being reduced by the machines is known as chlorination tailings and passed through a 12-mesh screen. The finished product delivered is 100-mesh.

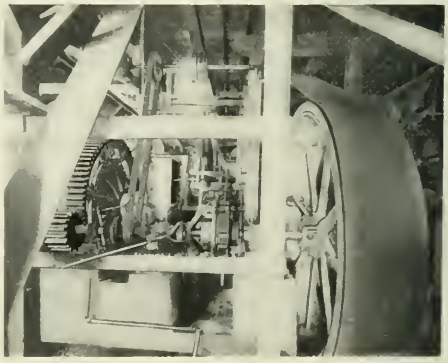


FIG. 2.—DRIVE OF TUBE MILLS.

The capacity of the machine is 160 tons each per 24 hours, which is certainly an remarkably high output for a machine of this size.

Fig. 1 shows the discharge ends of four of the tube mills, being one-half of the plant. These machines, as shown in Fig. 2, are driven by very large wood-split pulleys, which are belted direct to the motors.

Another feature of the plant worth while mentioning is that the tube mills, instead of having a spiral feed inside the mill, have the same attached on the outside to the trunnion. This

is an entirely new construction, and has proven itself to be just as satisfactory as the older method. The application is covered by numerous patents granted to Mr. Max F. Abbé, president of the Abbé Engineering Co.

Among the advantages of the "ideal" spiral feed are the following: It does not require a separate drive; it has no stuffing boxes; it does not wear out, get clogged up or break; it can be used for feeding the pebbles into the mill and the spiral discharge is used for discharging them, thus avoiding all labor of shoveling; it enables the loading of the mills with pebbles over the center, thereby decreasing the horse-power and increasing the capacity.

In wet grinding the machines are pumped two-thirds or three-fourths full, thereby practically doubling the grinding capacity and decreasing the horse-power still more.

Multimeter and Electroplaters' Voltmeter.

The Weston Electrical Instrument Co., of Waverly Park, Newark, N. J., have recently placed on the market two new instruments which have the advantage that each may replace a number of other instruments, thus permitting a considerable saving in the first cost of installation.

The Weston multimeter which is shown in Fig. 1, has its name derived from the fact that it may be used for an exceptionally large number of different measurements, since it will quite accurately serve the purposes of a direct-current voltmeter, milli-voltmeter, ammeter, mil-ammeter, ohmmeter, ground detector and wheatstone bridge. At the same time a much higher degree of accuracy is obtainable with it than with any so-called "universal instrument."

The multimeter consists of a Weston type wheatstone bridge, a battery of twelve silver chloride cells and an indicating instrument with detachable shunts.

The calibrated scale of the instrument has 160 divisions, with the zero placed at ten divisions from the end, so that when the instrument is used as a galvanometer in connection with the bridge, both positive and negative deflections may be observed.

FIG. 1.—MULTIMETER.

The shunts are fastened in a compact form to a single base. They have binding screws, and can easily be connected to the instrument by flexible cables about 6 feet in length, furnished with the instrument for that purpose. The shunts are constructed of Weston patent alloy having a negligible temperature coefficient, so that the combination of instrument and shunt is practically free from errors due to changes in temperature.

The wheatstone bridge, which forms a part of the multimeter, consists of a rheostat with three groups of coils, adjusted respectively to units, tens and hundreds, aggregating 999 ohms, and a set of five ratio coils. Many novel features are embodied in its construction, and its design is such that compactness and durability are combined with convenience of arrangement and an exceptionally high insulation resistance. All conductors and plug receptacles are placed under, instead of upon, the rubber top. This form of construction prevents any reduction in the insulation resistance as the under side of the rubber plate is not exposed to the deteriorating effects of light, dirt and moisture.

The large area of conductors employed, their compact arrangement and the absence of all temporary imperfect connections, together with the perfect fit of the five plugs, which are all that are required, make the "zero" resistance of the instrument less than that of any other portable bridge.

A push button is the only visible part of the double successive contact key, by means of which the galvanometer and battery circuits are made and broken.

A separate compartment in the case is provided for the battery, which consists of twelve cells connected together in series and fastened to a hard rubber top. A single cell may be used, or several in series. Any cell may easily be removed in case of necessity. Exhausted cells should be taken out, and if not replaced by others the terminals to which they are connected should be short circuited.

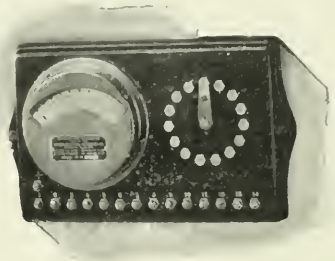


FIG. 2.—ELECTROPLATERS' VOLTMETER.

The second new instrument of the Weston Electrical Instrument Co. which we wish to describe in this article is a special voltmeter for electroplaters' use, and is shown in Fig. 2. Its special feature is that it may be used for measuring the voltage on any one of a number of plating tanks in an establishment up to fourteen. In other words, this instrument obviates the necessity of having a separate voltmeter for each tank and enables the plater to avail himself of an extremely accurate and reliable instrument at a very low cost. It has long been perfectly well understood that it is of utmost economy to control the electric current during the plating process carefully with the aid of measuring instruments, but the initial cost of installing an instrument for each of the plating tanks has been a great drawback. This drawback is now completely overcome.

The feature of the instrument is its combination, in one case, with a switch which permits, by simply turning a lever, to connect the instrument with any one of fourteen different circuits. Each of these circuits is, of course, connected with a different plating bath. In Fig. 2 the terminals of the fourteen different circuits are indicated by corresponding figures. It will be evident that the application of the instrument is exceedingly simple, since when the connections have once been made it is only necessary to turn the lever of the switch on the left-hand of Fig. 2 to the number of the tank to be tested and take a reading of the instrument.

A New Portable Combination Meter.

The unique combination of a voltmeter, ammeter, wattmeter and horsepower-meter in one instrument is accomplished in the "Victor" combination meter for direct current, manufactured by the H. W. Johns-Manville Co. This instrument was first placed on the market somewhat over a year ago, and was first designed for switchboard use in central stations. The success of the instrument for this purpose has recently lead to the placing on the market of a portable form for general electrical testing, an illustration of which appears herewith.

The "Victor" meter consists of two separate and complete instruments in a single case, the one giving readings in volts and the other in amperes. The third and fourth readings are obtained on a scale plotted at the center of the dial, giving the product, or power consumption, in watts or kilowatts and horsepower. These readings are taken at the points of intersection of the two indicators. The power scale is calibrated in "watts" or "kilowatts" on one side and "horsepower" on the other.

COMBINATION METER.

The convenience in having in one instrument a portable meter giving readings in volts, amperes, watts and horsepower is readily appreciated at a glance, as this meter is adapted for rapid testing in the laboratory as well as for field work.

If desired, multiple shunts and extra multipliers are furnished in connection with the volt and ampere scales for additional readings, and a table, containing the multiplying factor to be used with these various combinations when reading the central scale.

The Welding of Copper, Brass and Bronze by the Epurite Process.

The principal application of the epurite autogenous welding process is in the welding of iron and steel, as was described in the article of Mr. A. Beltzer on page 284 of our Vol. IV., but it is used now also for the welding of copper, brass and bronze, and it offers great advantages in this field.

The working of copper is especially interesting in piping. Heretofore copper piping has been brazed and is not always resistant. Numerous explosions have been caused by the slow destruction of the brazing under the influence of the voltaic elements formed by the presence of zinc and copper. The zinc is dissolved gradually by the inorganic acids from the impurities of the water and by the organic acids of oils which may obtain in the piping. The brazing is transformed into a copper sponge, absolutely non-resistant. With an autogenous weld, however, this defect disappears entirely.

In welding copper wire the tensile strength at the joint is never greater than two-thirds of the original tensile strength, and it is interesting to note that the wire breaks near the weld, but never at the weld itself. The reason of diminished strength is that the heat of the blow-pipe is concentrated on one part of the metal without being conducted away through the wire, copper becoming less resistant under the action of the heat.

Brass can be welded by using borax as a flux.

The epurite welding process can also be used with great advantage in repairing bronze and brass castings. The amount of money saved in repairing bronze castings is quite an item, as these castings are generally very costly. The cracks or flaws are first well cleaned, and when the metal begins to melt the holes are filled up by holding a bronze wire in the flame.

When two large surfaces of metal are to be joined together this is done by brazing with the blow-pipe. Sometimes it is better to braze copper than to weld it where the metal has to support elongation and bending, losing as it does some of its resistance near the welded point on account of the heat applied. The small dimensions of the oxy-acetylene flame allows the use of a brass wire, instead of the ordinary method, which can be melted with great accuracy into the joint to be filled. These brazings are clean and quickly made.

Autogenous Welding With the Oxy-acetylene Blow Pipe

In the preceding note we referred to the very interesting article by Mr. André Beltzer on the autogenous welding of iron by the oxy-acetylene blow-pipe and a new method of generating oxygen. The system described is that of the Industrial Oxygen Co., of New York City. The oxygen is obtained from epurite in contact with water, the acetylene from calcium carbide in contact with water. The arrangement of the apparatus as well as the principles of the oxy-acetylene flame were fully described by Mr. Beltzer.

A plant for autogenous welding by means of this process has recently been installed by the Worcester Pressed Steel Co. at Worcester, Mass. This is the second plant in this country, and the results which this company have obtained with the process in commercial operation should be of interest.

It has been established in practice that this process is valuable for replacing riveting and brazing in many instances. Two sheets of metal may be welded by placing their edges in contact and following along the seam with a blow-pipe. Practically seamless steel and copper tanks of almost any shape and size may be made by forming the body and ends separately and

FIG. 1.—WELDED STEEL TANK.

tracing the seams—joints butt and flush—with a blow-pipe. Many designs and forms, not otherwise possible to construct, are made practicable and feasible by this process.

This autogenous welding process is especially valuable in the foundry, as the blow-holes and similar defects in castings and forgings are made good. Cast iron, wrought iron, steel castings and forgings, copper, brass, bronze and aluminium in many forms of construction are effectively welded either in the manufacture of new parts or in repairing accidental breaks.

To insure strength, the joint is slightly overloaded by melting a wire or rod of same material as metal to be welded at the same time the edges are fused. The unfinished joint is stronger than the body of the metal and the finished joint is practically the same.

Any shaped hole can be easily cut in steel plates up to 6 inches in thickness, as with the blow-pipe the operator can accomplish cutting feats impossible with a saw. In cutting, the flame is proportionately elongated by pressure to penetrate to the bottom of the cut. The intense heat is so localized that the kerf is practically the same as if a saw were used.

No flux or moulds are required to weld metals such as iron, steel and copper, but for alloys, viz.: brass, bronze, etc., a little borax or boracic acid moistened with water is used simply to prevent the volatilized zinc from being deposited on the joint and destroying the weld. This process welds by fusion, forming a perfect metallic union of the parts which is imperceptible after finishing. It is not brazing.

It has been found that an operator of average ability can

weld steel or copper sheets at the rate and cost for gas approximately as follows:

	Per Inch.
.035" (about 1/32") .288" per hour	$0.0031
.062" (about 1/16") .200" per hour	.0065
.125" (about 1/8") .120" per hour	.016
.377" (about 3/8") .60" per hour	.075

Metals ¼ inch and less in thickness can ordinarily be welded cheaper than riveted. Steel and copper tanks for high and low pressure of almost any dimensions are effectively welded in place of riveting; broken steel shafts and other forgings repaired, cast iron welded, with copper or steel and blow-holes and similar defects in castings and forgings made good. The two adjoining illustrations show results obtained with the process, Fig. 1 representing a welded steel tank and Fig. 2 welded forged steel crank shafts.

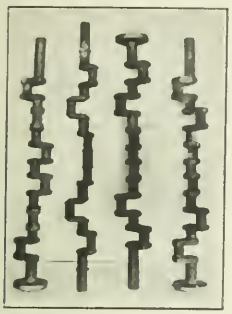


FIG. 2.—WELDED FORGED STEEL CRANK SHAFTS.

The Worcester Pressed Steel Co. have accomplished some difficult autogenous welding with aluminium, practically overcoming the trouble from the oxide which forms on the surface of aluminium when exposed to the atmosphere. Although aluminium melts at a comparatively low temperature (1,200° F.) it rapidly conducts and absorbs heat and requires a comparatively high local heat to obtain the best results.

Fertilizers from Atmospheric Nitrogen in America.

In view of the immense importance of the fertilizer problem, the utilization of nitrogen from the atmosphere for the production of nitrogen-containing fertilizers has been one of the most attractive propositions of electrochemistry. This problem has been attacked from quite different points of view. One line of work tends to use electric discharges through air to combine the nitrogen and oxygen contained in the air and subsequently to produce nitrates. The most noteworthy of all the researches carried out in this direction in this country has been the work of the Atmospheric Products Co. in Niagara Falls, under the patents and direction of Messrs. Bradley and Lovejoy. Though carried out on a comparatively large experimental scale it has not resulted in the establishment of a permanent industry, and the plant at Niagara Falls has been given up. Greater success has accompanied the work of Birkeland and Eyde in Norway, who are operating their process on a commercial scale.

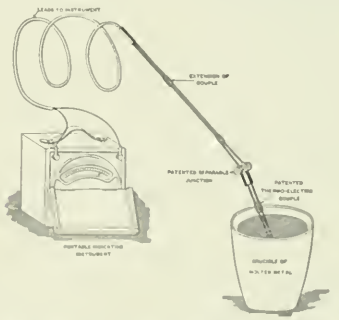
A second way of utilizing the atmospheric nitrogen for fertilizers is to start with calcium carbide as produced in the electric furnace and treat it at an elevated temperature with nitrogen which has been previously isolated from atmospheric air. The result is calcium cyanamide, or as the Germans call it, Kalkstickstoff (lime-nitrogen), the process being that of Frank and Caro. We have reported at length on developments in this direction in the past and may refer especially to the paper of Dr. Erlwein on page 77 of our present volume.

After the success which this process has achieved in Europe, the American Cyanamid Co. which was recently formed in this country, with headquarters at 100 Broadway, New York City, intends now to erect an initial plant of 20,000 metric tons annual capacity at Muscle Shoals, on the Tennessee River, in Northern Alabama. The reasons for selecting this location are given in a recent statement of the company as follows: "Here contiguous to the great Birmingham coal and iron district is cheap water power, the cheapest coke in the United States, limestone of unsurpassed quality and cheapness, and abundant and efficient labor. The advantages of this situation are unusual in respect to the facts; first, that the Tennessee River is one of the network of great interior navigable rivers of the Mississippi Basin, reaching the greatest agricultural regions of the country; second, that two great railway systems are available for reaching every market; third, Muscle Shoals is on the border of the great phosphate of lime deposits of Tennessee, with the acid product of which lime-nitrogen will be mixed universally in making the standard commercial complete fertilizers; and, fourth, the factory will be in the heart of the great cotton growing region of the United States, and close not only to the hundreds of fertilizer factories scattered throughout that section, but also to those which have clustered about the phosphate deposits."

As stated in Dr. Erlwein's paper referred to before cyanamide may also be used as a starting material for the production of sodium and potassium cyanide which are in such extended use in gold and silver metallurgy. The erection of a cyanamide factory in Mexico solely for this purpose is stated to be now under consideration.

A Portable Pyrometer for Instantaneously Taking Temperature of Molten Metals.

In manufacturing processes and in metallurgical work molten metals and alloys are extensively employed, especially for the making of castings from moulds, and it is of the utmost importance that the metals be mixed, alloyed and poured at the proper temperatures in order to obtain the best results. The special form of pyrometer described here has been designed to meet the practical requirements of everyday shop practice. The portable indicating instrument may be carried in the hand, and within two or three seconds the temperature of the molten



PYROMETER FOR MEASURING TEMPERATURE OF MOLTEN METALS.

metal may be taken. The possibilities and great value of an instrument of this kind will be fully appreciated by those who are interested in foundry work of any description.

The outfit complete consists of a portable indicating instrument connected to a special thermoelectric couple, the two elements of which are disconnected and left without insulation. When the tips of these elements are slightly immersed into the molten metal an electric connection is made and the reading on the instrument will be the same as if the couple had been originally joined.

The general arrangement of the parts forming the outfit for this class of temperature measurements is shown in the accom-

panying diagram as it would be applied for taking the temperature of a crucible of molten metal just before pouring.

The advantage of this plan is that the tips of the wires forming the elements almost instantaneously assume the temperature of the molten metal and time-lag error is eliminated.

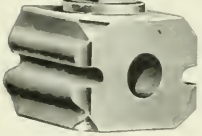
This form of couple has been most successfully applied to the measurement of molten metals, as cast iron, copper, aluminium, brass, bronze and other alloys.

When the tip of the couple becomes worn away by the continued use, a fresh portion is exposed to the molten metal and the reading will be the same as if the couple had not been reduced. A separable junction is provided, as shown in the diagram, so that fresh tips can be conveniently applied before enough of the couple has worn away to appreciably affect the resistance and cause an erroneous indication on the instrument. These instruments, which are being successfully used by a large number of manufacturers, are manufactured by William H. Bristol, 45 Vesey Street, New York City.

Stoneware Cocks.

As a substitute for threaded and flanged stoneware cocks in metal pipe lines, etc., the Charles Graham Chemical Pottery Works have designed and put on the market a cock in block form which has certain evident advantages, particularly those of strength and durability.

The cock consists of a block of stoneware, square in pattern, with longitudinal grooves on either side, as shown in the illustration. The faces at either end are ground true and parallel so that connection may be made directly to metal or other flange union, thus avoiding the necessity of lead burning.



STONEWARE COCK.

The grooves at the side are designed to accommodate bolts threaded at either or both ends, which are made fast in the flanges of the pipe sections.

These cocks are manufactured in sizes from ¾ inch to 3 inches. The larger sizes are made with two grooves on either side to accommodate four bolts. While the price of these cocks is slightly higher than for the ordinary plain or threaded straight-way cocks, they have the inherent advantage of being stronger than any other design of stoneware faucet, being practically a solid block of stoneware without any weak points. Where pipe lines and apparatus in chemical works are subject to more or less severe strain these cocks should be found most useful.

Notes.

Dry-Blast.—The Warwick furnace No. 2, at Pottstown, Pa., is being equipped for running with dried blast by the Gayley system. The refrigerating apparatus is now being installed at a cost of nearly $250,000, and will be ready for operation in August. Meanwhile, Mr. Edgar S. Cook and his able assistants are keeping very complete records of the running of the furnace in order that the effect of using the dried blast may be accurately estimated. As soon as complete figures will be available we will place them before our readers.

The American Electric Furnace Co., with offices at 45 Broad Street, New York City, has been formed to take over all the business pertaining to electric furnaces heretofore carried on by the American Gröndal-Kjellin Co., of New York, under the patents of Mr. F. A. Kjellin, and by the Induction Furnace Company, of Newark, under the patents of Mr. E. A. Colby. The patents of these two chief workers in the field of the induction furnace have therefore now become the property of one company. The American Gröndal-Kjellin Co. will continue to carry on as heretofore all business relating to the concentration and crushing of ores, the manufacture of charcoal and the other special processes which have been developed by Mr. Gustaf Gröndal and his associates.

Nürnberg Gas Engines.—The Vereinigte Maschinenfabrik Augsburg und Maschinenbaugesellschaft Nürnberg A. G., state in a recent circular that they have 250,000 hp. of their gas engines in operation, and furnish illustrated descriptions of some of their most recent installations, such as 3 machines of 1,950 hp. each, using blast furnace gas, at Differdingen; 4 of 900 hp, each, at Rombach in Lorraine; 4 of 2,700 hp. each, at Gelsenkirchen; 5 of 920 hp. each, using coke-oven gas, at Eschweiler, and 6 of 2,000 hp. each, using producer gas, at Madrid.

Fischer Gas Valve. The Fischer & Demmler Co., at Mülheim-on-the-Ruhr, claim that 173 of their open-hearth reversing valves are in use, with an average economy of 20 per cent fuel over any other type of valve. The advantages claimed are that there is no possibility of gas leaks, no interruption of gas supply to the furnace, and no sucking-in of cold air into the furnace as with other types.

The Stuart & Peterson Co., of Burlington, N. J., have issued their new catalogue No. 116, covering appliances for chemists, druggists, bottlers, soap manufacturers, etc. This catalogue illustrates their full line of steam-jacketed kettles, both plain and porcelain lined, which they manufacture in capacities ranging from 10 gallons up to 500 gallons. A full line of mixing and stirring apparatus, vacuum pans, portable stills, retorts percolators, emulsifiers and mixing machines are also illustrated; capacities of the various types of apparatus being given in full. This company also manufactures conveying kettles, caldrons, tanks and evaporating dishes with a high-grade porcelain lining which find considerable use among manufacturing chemists throughout this country. The manufacturers claim that the enamel used on their apparatus is the hardest known, and while it will resist most acids for years it is not guaranteed to stand extreme conditions indefinitely as an absolutely acid-proof enamel is unknown. Copies of the catalogue can be obtained from the Stuart & Peterson Co. on request.

Aluminium in Italy.—According to the *Electrical Review*, of London, May 24, an aluminium works has recently been erected near the town of Bussi, in the Abruzzi, by the Roman company which for some years past has owned a 4,000-hp. factory in the same neighborhood for the manufacture of caustic soda, bleaching powder, etc. A new power station has been built about 4 miles distant, and is developing power from the rivers Tirino and Pescara to the amount of 12,000 hp. From this station current is supplied to light and serve the towns of Aquila, Chieti and all the other places in the vicinity, and also to certain works where copper sulphate, artificial fertilizers and nitrogen compounds are being made. The aluminium factory is to obtain some of its bauxite from the mines at Lecce dei Marsi in the Province of Aquila, but the greater part will be procured from Japan.

Calcium Carbide in Ireland.—The *Electrical Review*, of London, remarks that there are a number of water powers in Ireland which might be used for the production of power for electrochemical processes. Several are being utilized for calcium carbide manufacture. Reference is made to an order recently placed by Mr. Frank Roadbent, consulting engineer, for a 640-hp. turbine coupled to a 430-kw-single-phase alternator. This forms the second set of this size for the works in question, and the turbine will operate on a 34-foot total fall and develop the power at 300 r. p. m. Owing to the possibility of getting the furnaces close up to the water power the alternators are run at low voltage, viz.: 50 volts, and are capable of developing up to 10,000 amps. They are self-regulating for constant output, and the turbines therefore are not hydraulically governed.

Glass Sand.—Approximately $65,000,000 worth of glass products were manufactured in the United States in 1905. The materials used cost about $18,000,000, and of this sum $1,000,000 was spent for sand. Sand forms from 52 to 65 per cent of the mass of the original mixture, or from 60 to 75 per cent of the finished glass products. The quality of the glass, its transparency, brilliancy and hardness, depend chiefly on the quality of the sand. Pennsylvania, Indiana and Ohio are the three chief States manufacturing glass products. In Bulletin 315, Contributions to Economic Geology, of the United Geological Survey, Mr. E. F. Burchard discusses the rock formations which in Ohio, Indiana and Kentucky furnish sand suitable for glass making and gives descriptions of the various properties now being developed.

Gas Power.—From a pamphlet of the Wile Power Gas Co., of Rochester, N. Y., manufacturers of complete gas power installations, gas producers and engines, we take the following figures of the fuel costs of 1-hp. year, generated from

	Per Hp-year.
Electricity, at 2 cents per horsepower-hour	$90.00
Gasoline, at 15 cents per gallon	45.00
Illuminating gas, at 75 cents per 1,000 cu. ft.	40.00
Cut-off steam engine, with coal at $4 per ton	24.00
Natural gas, at 30 cents per 1,000 cu. ft.	10.00
Producer gas from coal, at $4 per ton	6.00

In the above table, for steam power, a consumption of 4 pounds of coal per horsepower-hour has been assumed, which is exceedingly good non-condensing practice and only realized in large engines. Producer-gas power is cheap power, not only in fuel but also in attention required. The Wile Power Gas Co. manufacture gas producers to use non-bituminous coals, such as anthracite, semi-anthracite, coke and charcoal, as well as gas producers for bituminous fuels, such as soft coal, lignite, peat and wood, which operate with the same efficiency as the non-bituminous producers. These producers are tar-destroying and continuous cleaning.

Electrically-Singed Cotton Yarn.—At the recent cotton exposition in Philadelphia there was an interesting exhibit of an electric singeing method of cotton yarn which is an invention of Count von Moltke. The process is now being introduced in this country by the Société Electro-Textile, Messrs. Garner & Co., 10 Worth Street, New York City, being the agents. Connected with the usual processes of gassing yarns and cloths are several important disadvantages. Firstly, the cost of the gas consumed is very high, at least 95 per cent of the heat being wasted, which often renders a complicated and expensive system of ventilation necessary to reduce the temperature of the operating rooms and to withdraw the obnoxious gases of combustion. Secondly, variations in the pressure of the gas at different hours of the day cause a corresponding irregularity in the degree of gassing, which may be still further increased by the slightest current of air in the vicinity of the burners. Finally, materials under treatment are often discolored by impurities in the gas and acquire more or less of an odor. The electric singeing with its marked superior thermal efficiency disengages very little waste heat, the yarns are less discolored and their odor is less noticeable. Furthermore, the process permits of a perfect regulation of temperature to suit the various sizes and running speeds of the materials. As the "voltage per burner" does not exceed 3 volts there can be no danger to operators.

Belgian Zinc Industry.—A recent consular report of Mr. J. C. McNally deals with the zinc industry in Liege and in Belgium in general. In 1906 the zinc market was particularly active and the demands exceeded the supply. The yearly average price was $129.94 per metric ton (2,205 pounds), or $8.12 higher than in the previous year. In 1906 the Liege Company produced 93,640 tons of ingots, 67,253 tons of rolled sheets, and 9,442 tons of oxide. Of the latter the United States received $43,690 worth. The ore production of the company in various parts of the world for 1906 was 123,954 tons of zinc and 5,832 tons of lead ore. They also imported 158,624 tons of ores purchased abroad. The total importation of zinc ores in to Belgium during 1906 amounted to 523,696 tons, of which Sardinia furnished 109,040 and Australia 122,279. The production of spelter in Belgium was 150,660 tons in 1906 against 143,300 tons in 1905. The total production of spelter in the United States, Europe and Australia is given as 690,965 tons against 647,720 in 1905. Following is a table of the production and the quantities contributed by the different countries:

	1906. *Tons*	1905. *Tons.*
United States	198,910	189,360
Belgium	150,660	143,300
Rhine district, Germany	67,615	66,185
Holland	14,420	13,550
Great Britain	51,760	50,125
France and Spain	52,940	49,575
Silesia, Germany	134,180	127,895
Austria and Italy	10,610	9,210
Poland, Germany	9,460	7,520
Australia	1,010	.....
Total	690,965	647,720

The average price of spelter ex ship London in 1906 was $136.29, against $122.79 in 1905. The average price of lead in 1906 was $83.97 per metric ton, against $76.48 in 1905.

Canadian Department of Mines.—At the last session of the Canadian Parliament a Department of Mines was created with a minister of the Crown in charge of it. The department consists of two branches: the Mines Branch and the Geological Survey Branch. The latter was formerly a separate department, but has now been abolished as such and made into a branch of the Department of Mines. The direction of the work of the Mines Branch dealing with all economical matters is in charge of the Director of Mines, Dr. Eugene Haanel who has so highly distinguished himself during the last years in the electrometallurgy of iron and steel.

The **Stevens Institute of Technology** has appointed Miss E. M. Hawkins, graduate of the Pratt Institute Library School, to take charge of its library. An important feature of the library is that section devoted to patent literature, containing the patent gazettes and specifications. Prof. W. H. Bristol has contributed liberally to the support of this section.

Colorado School of Mines.—We have received Vol. 1, No. 2 of the *Quarterly* of the Colorado School of Mines, Golden, Col. It contains on 150 pages full information on history, organization and equipment, the courses offered, etc. The number of students is at present 204.

The General Electric Company's San Francisco office is now permanently located in the Union Trust Building in San Francisco. Since the fire the office has been located in the Union Savings Bank Building at Oakland, large temporary warehouses having also been erected in the same city.

Electric Smelting of Iron Ore in California.—The plant of the Noble Electric Steel Co. at Heroult-on-the-Pit, is now in course of erection. Dr. Heroult has arrived at the spot where his engineers, Messrs. Furnald, Petmot and Humbert, had preceded him to assist in the erection of the electric furnace plant.

Electrodeposition of Iron.—In the London *Electrical Engineering* of June 13 we notice mention of a recent patent of Sherard Cowper Coles for the electrodeposition of iron, suitable for the production of tubes, sheets or wire, with a bright smooth surface, from a solution which is maintained charged with iron oxide. The solution contains 20 per cent of sulpho cresylic acid saturated with iron, and the current density is 100 amps. per square foot of cathode surface. The voltage

to 3.25, the distance apart of anode and cathode ½ inch, and the temperature of the electrolyte is maintained at exactly 70° C.

Electric Tube Furnace.—The Fery-Langlet tube furnace, which was exhibited at the recent exposition of the French Physical Society in Paris, and is described in *La Revue Electrique* May 30. The tube consists of magnesia, which is impermeable for gases and is not reduced by carbon at temperatures up to 2,000 C. This magnesia tube is surrounded by a graphite tube into which is cut a helical slot so as to form a helical graphite resistor. The electric current in passing through this graphite helix generates the heat. The graphite resistor is protected against oxidation by packing around it a dense layer of powdered carbon, which is a poor conductor of electricity and heat, the whole being included in a metallic envelope. When the furnace is heated for the first time the powdered carbon combines with the oxygen of the air within the envelope so that an inert atmosphere of oxide of carbon and nitrogen is produced.

French Electrochemical Society.—In a recent issue of the *Revue d'Electrochemie et d'Electrometallurgie* the suggestion is made to form a French Electrochemical Society. While the United States, Germany and England have their electrochemical societies none has been formed in the past in the country of Berthelot, Moissan and Heroult, where so much has been accomplished in recent years in industrial electrometallurgy.

Bunsen Society.—The annual convention of the Bunsen Society was recently held in Hamburg. One of the features was a symposium of papers on radioactivity. A full report will be given later.

American Electrochemical Society.—At the meeting of the board of directors, held in Philadelphia on June 1, the following gentlemen were elected members of the society: Allerton S. Cushman, chemist of the Department of Agriculture, Washington, D. C.; Royd R. Sayers, instructor in electrochemistry, Indiana University, Bloomington, Ind.; John F. Hammond, electrical designer, S. S. White Dental Manufacturing Co., Princes Bay, S. I., N. Y.; J. B. DuFaur, assayer, Mt. Morgan Gold Mining Co., Turramurra, Sydney, Australia; John L. Tufts, chemical engineer, Merrimac Chemical Co., Winchester, Mass.; William M. Grosvenor, consulting engineer, 1202 Townsend Building, Twenty-fifth and Broadway, New York City; J. Forsell, chemist, National Carbon Co., Cleveland, Ohio; Joseph B. Crane, assistant foreman, testing department, General Electric Co., Schenectady, N. Y.; George A. Richard, director, Electrolytic Refining Co., Mt. Morgan, Queensland, Australia; John F. Queeny, president, Monsanto Chemical Works, St. Louis, Mo.; Frank W. Liepsner, assistant in chemistry, University of Missouri, Columbia, Mo.; Charles F. Lindsay, research chemist, General Electric Co., Schenectady, N. Y.; Roger C. Wells, instructor in physical chemistry, University of Pennsylvania, Philadelphia, Pa.; A. Henry Pikler, electrical engineer, Crocker-Wheeler Electric Co., Montclair, N. J.; Stanislaus Skowenski, chemist, American Smelting & Refining Co., 54 High Street, Perth Amboy, N. J. At the meeting of the board of directors, held in New York City on June 29 the following gentlemen were elected members of the Society: Walter E. F. Bradley, electrochemist, New York City; Leland M. Willey, chemist, General Electric Co., Schenectady, N. Y.; Walter Renton Ingalls, editor, *Engineering and Mining Journal*, New York City; Herbert R. Moody, associate professor of chemistry, Stevens Institute Hoboken, N. J.; Alcan Hirsch, student of chemistry, University of Texas, Austin, Tex.; Fritz Zimmerman, chemist with Baker & Co., Newark, N. J.; Harry McCormack, associate professor of industrial chemistry, Armour Institute, Chicago, Ill.; Morris Medove, student electrical engineer, Newark, N. J.; J. Harry Casselberry, electrician, Pennsylvania Railroad, Altoona, Pa.; Heinrich Wohlwill, electrochemist, Norddeutsche Affinerie, Hamburg, Germany. The next meeting of the Society will be held in Autumn, in New York City. While the exact date has not yet been decided upon, it will probably be held early in October. One of the features of the meeting will be a symposium of papers on the electrometallurgy of iron and steel.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

Calcium Carbid (*Continued*).

No. 562,402, June 23, 1896, W. R. King and F. Wyatt, of New York, N. Y.

Produces a nugget or ingot of calcium carbid in a pile of pulverized coke and lime, preferably equal parts, by placing a vertical resistance rod of carbon or coke in the pile, with its ends in contact with terminal electrode rods of larger cross-section. The upper terminal is carried by slides and rests directly upon the core, thereby maintaining contact as the core and charge fuse and shrink. The charge-material may be heaped around the core, or may be first piled up and the core pushed down into it. The pile may be shored up by planks or bricks. A direct or alternating current is passed through the core until lowered voltage or increased resistance shows that the current is no longer fusing the charge. The gases pass to the surface of the heap and burn. If they escape too freely at any point the workmen shovel charge-material onto the flame. Notwithstanding the high temperature required to produce calcium carbid, specified as about 5,000° F., the surface of the mound, except where the gases are burning, does not feel uncomfortably warm to the hand. At the end of the operation the white-hot ingot, which replaces the core, is lifted out, for example, by tongs carried on a swinging frame, a new core is put in place and the material piled around it for another operation. The process is said to be applicable to the production of carbids of other alkali and alkaline-earth metals.

No. 563,527, July 7, 1896, Thomas L. Willson, of New York, N. Y.

Subjects a mixture of finely-divided anhydrous calcium oxid, 65 per cent, and carbon, preferably coke, 35 per cent, to the action of an electric arc in a furnace. Hydrocarbons may be added to the charge, or the lime may be saturated with a liquid hydrocarbon. The furnace is preferably a graphite crucible connected to one terminal and receiving a carbon pencil connected to the other terminal. In starting the carbon pencil is brought into contact with the crucible, then lifted to strike an arc, and lifted during the operation to maintain the arc by maintaining a space between the pencil and the conductor beneath. Disclaims the making of metallic alloys by alloying the metal of the electrode with the metal of a bath.

No. 563,528, July 7, 1896, Thomas L. Willson, of Brooklyn, N. Y.

Produces calcium carbid by smelting a mixture of powdered quicklime and coal in *e. g.*, a Siemens arc furnace. Or the lime may be slacked and stirred into liquid coal tar, dried and smelted. Or the lime and carbonaceous matter may be charged into the furnace during the smelting operation. Or the heavy carbon pencils or slabs of the furnace may serve as the scource of carbon, though this is uneconomical. The carbid may be tapped out of the furnace at a white heat, or may be removed at the end of the operation. It is friable and iron-gray or bluish-gray. If exposed to the air it gradually crumbles to powder, its surface turning to a whitish-gray by oxidation to lime. It may be preserved in moisture-excluding vessels or beneath oil. The second step of the invention is the production of acetylene from the carbid by dropping it into water, 1 pound of carbid giving about 5.5 cubic feet of acetylene. The Third step of the invention is the production of an illuminant by mixing the acetylene with atmospheric air. The acetylene may be used to enrich water-gas, producer-gas or other illuminating gas.

NEW BOOKS.

Commercial Organic Analysis. A treatise on the properties, modes of assaying and proximate analytical examination of the various organic chemicals and products employed in the arts, manufactures, medicines, etc., with concise methods for the detection and determination of their impurities, adulterations and products of decomposition. By Alfred H. Allen. Third edition; rewritten and revised. Vol. II., Part III. Acid derivatives of phenols, aromatic acids resins and essential oils. Revised by the author and Arnold Rowsby Tankard. 547 pages; 2 illustrations and numerous tables. Bound in cloth. Price, $5.00 net. Philadelphia: P. Blakiston's Son & Co.

Outlines of Industrial Chemistry. A text book for students. By Frank Hall Thorp. Second revised and enlarged edition, with a special chapter on metallurgy by C. D. Demond. 733 pages; illustrated. Bound in cloth. Price, $3.75 net. New York: Macmillan Co.

Metallurgical Calculations. By Joseph W. Richards, A. C., Ph. D., professor of metallurgy in Lehigh University. Part II.: Iron and Steel. 444 pages. Price, $2.00. New York: McGraw Publishing Co.

Library of Congress: Select List of Books with Reference to Periodicals Relating to Iron and Steel in Commerce. Compiled by A. P. C. Griffin. 25 pages. Paper binding. Price, 15 cents. Washington, D. C.: Office of the Superintendent of Documents.

Further Researches Concerning Atomic Weights of Potassium, Silver, Chlorine, Bromine, Nitrogen and Sulphur. By Theodore W. Richards, Arthur Staehler and others. Paper binding. 88 pages with diagrams and illustrations. Price, 50 cents. Washington, D. C.: Carnegie Institution of Washington.

The Compressibility of the Elements and Their Periodic Relations. By Theodore W. Richards, W. W. Stull, F. N. Burk and F. Bonnet, Jr. 67 pages; illustrated; paper cover. Price, 50 cents. Washington, D. C.: Carnegie Institution of Washington.

Mathematics for Engineering Students; Algebra and Trigonometry. By S. S. Keller. 254 pages; illustrated. Price, $1.50 net. New York: D. Van Nostrand Co.

Mine Timbering. By Wilbur E. Sanders, Bernard McDonald and Norman W. Parlee. 180 pages; illustrated. Bound in cloth. Price, $2.00 net. New York: Hill Publishing Co.

Mines and Minerals. Examination questions for certificates of competency as mine inspector, mine foreman, mine manager, fire boss, hoisting engineer, etc., as given by the State Examining Boards, together with answers. 600 pages; illustrated. Price, $3.50 net. Scranton, Pa.: Mines and Minerals.

Preliminary Account of Goldfield, Bullfrog and Other Mining Districts in Southern Nevada. 104 pages; illustrated by maps and drawings. Paper binding. 15 cents. Washington, D. C.: Superintendent of Documents.

Gold Supply and Prosperity. By Byron W. Holt. 180 pages; illustrated. Bound in cloth. Price, $1.00 net. New York: Moody Corporation.

Laboratoriumsbücher für die Chemische und Verwandte Industrien. Edited by Max Wohlgemuth, literarisch wissenschaftlichem Beirat in der Chemischen Fabrik Th. Goldschmidt, Essen-Ruhr. Vol. I. Laboratoriumsbuch für den Eisenhüttenchemiker. By Max Ortbey. 40 pages. Price, mark 1.80 (retail price in New York, 60 cents). Halle a. S.: Wilhelm Knapp.

German Monographs on Methods of Manufacture in Chemical Technology. Edited by I. Max Wohlgemuth, Halle a. S.: Wilhelm Knapp:

Vol. I. "Der Fabrikchemiker, seine Ausbildung und Stellung." By L. Max Wohlgemuth. Price, mark 1.

Vol. II. "Die Industrie des Braunkohlenteers." By Dr. Ed. Graefe. Price, mark 3.60.

Vol. III. "Die deutsche Kaliindustrie." By Dr. Konrad Kubierschky. Price, mark 3.80.

Vol. IV. "Das Porzellan." By Dr. R. Dietz. Price, mark 3.20.

Vol. V. "Die Superphosphatfabrikation." By Dr. Ritter von Grueber. Price, marks 3.

Vol. VI. "Die Fabrikation von Sulfat und Salzsäure." By Dr. Theodor Meyer. Price, marks 3.40.

* * *

At the suggestion of some correspondents we herewith give a complete list of all volumes which have so far been published in the serial of German Monographs on Applied Electrochemistry, edited by Victor Engelhardt and published by Wilhelm Knapp, Halle a. S. We also state whether a translation into English has been published.

Vol. I. "Electrolysis of Water, Its Operation and Applications." By Victor Engelhardt. Price (in German) marks 5. English translation by J. W. Richards. $1.25. Easton, Pa.: Chemical Publishing Co.

Vol. II. "The Manufacture of Aluminium and Its Uses in Commerce and Industry." By A. Minet and E. Abel. Price, marks 7. English translation by L. Waldo. $2.50. New York: John Wiley & Sons.

Vol. III. "The Manufacture of Chromium and Its Compounds with the Aid of the Electric Current." By Prof. Max LeBlanc. Price (in German), marks 6. English translation by J. W. Richards. $1.25. Easton, Pa.: Chemical Publishing Co.

Vol. IV. "The Arrangement of Electric Laboratories with Special Reference to the Requirements of Metallurgical Practice." By H. Nissenson. Price (in German), marks 2.40. English translation by J. W. Richards. $1.25. Easton, Pa.: Chemical Publishing Co.

Vol. V. "The Production of Metallic Objects Electrolytically and Electroengraving." By Dr. W. Pfanhauser. Price (in German), marks 7. English translation by J. W. Richards. $1.25. Easton, Pa.: Chemical Publishing Co.

Vol. VI. "Electrometallurgy of Nickel." By Prof. W. Borchers. Price, marks 1.50 (only in German).

Vol. VII. "Cyanide Processes for Winning Gold." By M. von Uslar and Dr. G. Erlwein. Price, marks 4 (only in German).

Vol. VIII. "Hypochlorites and Electric Bleaching. Operation in Practice." By Victor Engelhardt. Price, marks 1.2 (only in German).

Vol. IX. "Electrometallurgy of Alkali Metals." By H. Becker. Price, marks 6 (only in German).

Vol. X. "Electrolytic Refining of Copper." By Titus Ulke. Translated into German by Victor Engelhardt. Price, marks 8. The original American edition is published under the title "Modern Electrolytic Copper Refining," by Titus Ulke. Price, $3.00. New York: John Wiley & Sons.

Vol. XI. "Galvanoplastik." By W. Pfanhauser. Price, marks 4 (only in German).

Vol. XII. "The Electrochemical Industry of Germany." By Dr. P. Ferchland. Price, marks 2.50 (only in German).

Vol. XIII. "Carborundum." By F. A. J. FitzGerald. Translated by Dr. Max Huth. Price, marks 2 (only in German).

Vol. XIV. "Electrolytic Preparation of Parabolic Mirrors." By Sherard Cowper Coles. Translated by Dr. Emil Abel. Price, mark 1 (only in German).

Vol. XV. "Artificial Graphite." By F. A. J. FitzGerald. Translated by Dr. Max Huth. Price, marks 3 (only in German).

Vol. XVI. "Electrolytic Production of Zinc." By Dr. Emil Günther. Price, mark 10 (only in German).

Vol. XVII. "Hypochlorites and Electric Bleaching. Theory." By Dr. Emil Abel. Price, marks 4.50 (only in German).

Vol. XVIII. "Electroplating with Zinc." By Sherard Cowper-Coles. Translated by Dr. Emil Abel. Price, marks 2 (only in German).

STANDARD BOOKS

METALLURGY

ORE DRESSING
By ROBERT H. RICHARDS
Of the Massachusetts Institute of Technology
Two volumes, 6½ x 9½, cloth, 1250 pages, profusely illustrated, per set $10.00.

MODERN COPPER SMELTING
By EDWARD DYER PETERS
600 pages 6½ x 9½, cloth, $5.00.

PRINCIPLES OF COPPER SMELTING
By EDWARD DYER PETERS
Professor of Metallurgy, Harvard University
612 pages 6½ x 9½, cloth, $5.00.

PYRITE SMELTING
By T. A. RICKARD
210 pages 6½ x 9½, $2.00.

THE METALLURGY OF LEAD
By H. O. HOFMAN
Professor of Metallurgy, Massachusetts Institute of Technology
600 pages 6½ x 9½, $6.00.

HYDROMETALLURGY OF SILVER
By OTTOKAR HOFMANN
336 pages 6½ x 9½, cloth, $4 00.

MANUFACTURE AND PROPERTIES OF IRON AND STEEL
HARRY HUSE CAMPBELL
640 pages, 6 x 9, illustrated, $5.00.

METALLURGICAL CALCULATIONS
PART I. CHEMICAL PRINCIPLES
By PROF. JOSEPH W. RICHARDS
200 pages, cloth, $2.00 net.

METALLURGICAL CALCULATIONS
PART II. IRON AND STEEL
By PROF. JOSEPH W. RICHARDS
250 pages, cloth, $2.00 net.

IRON, STEEL AND OTHER ALLOYS
By PROF. HENRY M. HOWE
Second edition, 513 pages, 123 illustrations. Price $5.00 net.

METALLURGICAL LABORATORY NOTES
By PROF. HENRY M. HOWE
154 pages, 44 illustrations. Price, $2.50 net.

In this book the author describes ninety-one laboratory experiments conducted by students in the Department of Metallurgy of the School of Mines of Columbia University, and deals with Pyrometry, Calorimetry, Metallography, Heat Treatment of Steel, etc

ELECTROMETALLURGY

ELECTRIC SMELTING AND REFINING
By DR. W. BORCHERS. Translated by W. G. McMILLAN.
Second edition, 562 pages, 255 illustrations. Price, $7.00.

This book treats of all those metals in the extraction and working of which the electric current has found any application. A survey of the purely metallurgical methods of treatment has been added to each chapter, so the two methods may be readily compared.

THE ELECTRIC FURNACE
By HENRI MOISSAN
Authorized Translation By DR. VICTOR LENHER
305 pages, illustrated. Price, $2.50.

A complete description of this recent apparatus and its application to the fusion and volatilization of refractory substances. The work is brought up to date by accounts of recent development.

Any of the above books sent postpaid on receipt of price.

We can promptly furnish any Metallurgical, Chemical or Engineering book.

ELECTROCHEMICAL PUB. CO.

Book Dept. 114 Liberty St, New York

Vol. XIX "The Electrolytic Chlorate Industry." By J. B. C. Kershaw. Translated by Dr. Max Huth. Price, marks 6 (only in German).

Vol. XX. "Electrolysis of Fused Salts." Part I., Compounds and Elements. By Prof. R. Lorenz. Price, marks 8 (only in German).

Vol. XXI. "Electrolysis of Fused Salts." Part II., Faraday's Law, Transport and Migration of Ions, Conductivity. By Prof. R. Lorenz. Price, marks 8 (only in German).

Vol. XXII. "Electrolysis of Fused Salts." Part III., Electromotive Force. By Prof. R. Lorenz. Price, marks 10 (only in German).

Vol. XXIII. "Electrolysis of Alkali Chlorides with Fused Metallic Cathodes." By Dr. R. Lucion. Price, marks 9 (only in German).

Vol. XXIV. "German Patents Relating to Electrochemistry." By Dr. P. Ferchland and Dr. P. Rehländer. Price, marks 10 (only in German).

Vol. XXV. "German Patent Law for Chemists." By Dr. P. Ephraim. Price, marks 18 (only in German).

Vol. XXVI. "Electrometallurgy of Iron and Steel." By Prof. B. Neumann. Price, marks 7 (only in German).

Vol. XXVII. "Electrolytic Production of Bromine and Iodine." By Dr. Max Schlötter. Price, marks 2.40 (only in German).

BOOK REVIEWS.

Metallurgical Calculations. Part II., Iron and Steel. By Joseph W. Richards, A. C., Ph. D. 444 pages. Price, $2.00 net. New York: McGraw Publishing Co.

This is a reprint in book form of the series of articles which appeared in Electrochemical and Metallurgical Industry from April, 1906, to May, 1907. "The intention is to show how the general chemical, physical and mechanical principles which were elucidated at length in Part I., can be applied to solving the special problems arising in the metallurgy of iron and steel. To this end descriptions of processes have been made as brief as was consistent with the clear statement of the particular principles involved, and familiarity with the general principles explained in Part I. has been assumed. To gain advantage from the use of this work, the student or reader should master the principles taught in Part I., and possess a certain body of information as to the modus operandi of the various processes of making iron and steel."

The twelve chapters of the book deal, respectively, with the material balance sheet of the blast furnace; calculation of a furnace charge; utilization of fuel in the blast furnace; the heat balance sheet of the blast furnace; rationale of hot blast and dry blast; production, heating and drying of blast; the Bessemer process; thermochemistry of the Bessemer process; the temperature increment in the Bessemer converter; the open-hearth furnace; thermal efficiency of open-hearth furnaces; the electrometallurgy of iron and steel. The principles are fully illustrated in eighty problems, the solutions of which are given in full.

An appendix contains twenty additional problems for practice, without solution, although the final answer is given.

* * *

Table of Volumes Through Air-Ways. By C. H. Kuderer. Pasted on cardboard. Price, 25 cents. Allegheny, Pa.: E. E. Meyer.

This is a table of volumes through air-ways in cubic feet per minute, calculated on the basis of Atkinson's formula, by Mr. H. C. Kuderer, general manager of the Avonmore Mine Fan Co. The table is very handy and should prove useful as reference for engineers who meet with problems of air transmission through large air-ways.

A Text Book of Electrochemistry By Max Le Blanc, professor in the University of Leipzig Translated from the fourth enlarged German edition by Willis R. Whitney, Ph. D., director of the research laboratory of the General Electric Co., and John W. Brown, Ph D., director of the research and battery laboratory of the National Carbon Co. 338 pages; illustrated. Price, $2.00 net. New York: The Macmillan Co.

We have recently commented on the fourth German edition of this excellent textbook. Almost simultaneously with it the American edition has appeared. Compared with the first American edition, which was a translation of the first German edition, the new edition is almost a new book. The translators have paid special attention to notation and nomenclature, and their endeavors in this direction deserve more than passing notice.

While the nomenclature has been made to conform to that of the best recent textbooks of electricity and chemistry, a complete, consistent system of notation has been devised which is used uniformly throughout the book We believe that this has never been done before with equal consequence. There may be details in which others will disagree with Dr. Whitney and Dr. Brown. For instance, they use the symbol c for electric current; this is decidedly English usage, while in this country, France and Germany, electrical engineers prefer the symbol i. The translators write Q underscored for the electrochemical unit of quantity of electricity, *i. e.*, 96,540 coulombs, while the symbol F (Faraday) is now being widely used for the same quantity. In the Whitney-Brown system F stands for force both for mechanical force and for electromotive force—which are two very different things, so that they have to be distinguished by indices. But all such objections are small matters. The fact remains that the notation used by the translators is consistent in itself.

Prof. Le Blanc now occupies Ostwald's old chair in Leipzig, while Dr. Whitney and Dr. Brown are prominently connected with industrial progress in this country It is therefore but natural that their textbook is not only a reliable and representative statement of modern theory, but that it is a statement in such form as to make the theory applicable to the needs of the research chemist for industrial ends.

* * *

Populäre Schriften. By Ludwig Boltzmann. 440 pages. Price in paper cover, marks 8; bound, marks 9 (retail price in New York, $2.65 and $3.00, respectively) Leipzig: Johann Ambrosius Barth.

Ludwig Boltzmann was one of the most brilliant and successful leaders and workers in theoretical physics His influence was very widely felt, his strong personality impressed itself on many of the advances which have been made in thermodynamics and gas theory, in the development of Maxwell's electromagnetic theory, in the principles of mechanics, etc. In the preface to one of his volumes on Maxwell's theory he quotes the sentence: "Wenn die Könige baun, haben die Karrner zu thun." He refers to Maxwell as a König and to himself, with utmost modesty, as a Karrner. But we know that he was far more. If he had done nothing else and he has done so much more—the Boltzmann-Stefan radiation law would make his name immortal.

Boltzmann was not only a clear-headed and immensely resourceful physicist and brilliant mathematician, he was a man of strongest personality. Many of his most characteristic human traits are exhibited in the present book, which is a collection of his "popular writings" and which appeared not long before his lamentable death by his own hand last Autumn.

The title, Popular Writings, is very indefinite and may even be misleading. The twenty three articles, papers, lectures and reviews collected in the book are of a very heterogeneous character. Article No. 1 deals with "the methods of theoretical physics," explaining the usefulness of dynamical illustrations and mechanical analogies. Article 2 gives a concise

JUST READY

"FOODS AND THEIR ADULTERATIONS"

The Origin, Manufacture and Composition of Food Products, Description of Common Adulterations, Food Standards, and National Food Laws and Regulations

By HARVEY W. WILEY, M. D.

Chief Chemist, U. S. Department of Agriculture, Washington, D. C.

A guide to the chemist in detecting impurities in food.

11 Colored Plates and 86 other Illustrations

Octavo: 625 pages Cloth, $4.00 net

Synopsis of Contents: —Introduction.—Meats.—Poultry and Game Birds.—Fish Foods.—Milk and Milk Products. Cereal Foods.—Invalid and Infant Foods.—Vegetables, Fruits, Spices, Nuts, Etc.—Sugar and Honey.—Food Standards, Rules and Regulations for Enforcing the Food and Drugs Act.—Regulations Governing Meat Inspection.—Index.

Orders may be sent to any bookseller; or upon receipt of price we will forward to any address, postage or express charges prepaid.

P. Blakiston's Son & Co.

SCIENTIFIC PUBLISHERS

1012 Walnut St., Philadelphia

Handbook of Mathematics

FOR ENGINEERS AND ENGINEERING STUDENTS

By J. CLAUDEL

Translated and Edited from the Seventh French Edition by OTIS ALLEN KENYON

A complete book on Mathematics
It covers very thoroughly
Every branch from Arithmetic to Calculus

TABLE OF CONTENTS

Part I.—Arithmetic. I.—Fundamental Operations on Whole Numbers. II.—Properties of Whole Divisors. III.—Fractions and Decimal Numbers. IV.—Powers and Roots. V.—Ratios Proportions, Progressions. VI.—Diverse Rules. VII.—Logarithms. Part II.—Algebra. I.—Of the Four Fundamental Algebraic Operations. II.—Equations of the First Degree. III.—Powers and Roots of the Algebraic Quantities. IV.—Equations of the Second Degree. Part III.—Geometry. Plane Geometry. Solid Geometry. Problems in Geometry. Part IV.—Trigonometry.—Plane. Spherical Trigonometry. Part V.—Analytical Geometry. Part VI—Calculus. I.—Differential Calculus. II.—Integral Calculus. III.—Applications of Integral Calculus.

Cloth, 708 Pages. 422 Illustrations. Price, $3.50 Net.

Sent anywhere postpaid for the price

Send Us Your Inquiries Write For Our Catalogs

McGraw Publishing Company

PUBLISHERS, IMPORTERS AND BOOKSELLERS

114 Liberty Street, New York

DUHEM-BURGESS—*Thermodynamics and Chemistry.* A Non-Mathematical Treatise for Chemists and Students of Chemistry. By P. Duhem, Correspondant de l'Institut de France; Professor of Theoretical Physics at the University of Bordeaux. Authorized Translation by George K. Burgess, Docteur de l'Université de Paris; 8vo, xxi+445 pages, 140 figures. Cloth, $4.00.

GETMAN—*Laboratory Exercises in Physical Chemistry.* By Frederick H. Getman, Ph. D., Fellow by Courtesy of The Johns Hopkins University, Carnegie Research Assistant. 12mo, viii+241 pages, 100 figures. Cloth, $2.00 net.

LÖB-LORENZ—*Electrochemistry of Organic Compounds.* By Dr. Walther Lob, Privatdocent in the University of Bonn. Authorized Translation by H. W. F. Lorenz, A.M., Ph.D., 8vo, x+308 pages, 10 figures. Cloth, $3.00.

WEAVER—*Notes on Military Explosives.* By Erasmus M. Weaver, Lt. Col. Artillery Corps, U. S. Army. 8vo, viii+311 pages. Cloth, $3.00 net.

JOHN WILEY & SONS
43 & 45 E. 19th St., New York City

Eleventh Edition

Metallurgy of Cast Iron

A complete exposition of the processes involved in its treatment, chemically and physically, from the blast furnace through the foundry to the testing machine, being a practical compilation of original research.

By THOMAS D. WEST

Contents

PART I.—Manufacture and Use of Coke—Properties in Ores—Operations of Blast Frunaces—The Different Brands of Pig-Iron and How to Purchase and Use Them Intelligently (27 chapters). II.—Elements in Cast-Iron and Their Physical Effect—Utility of Chemical Analyses and How to Use Them in Making the Different Mixtures of Irons Used in Making Gray and Chilled Castings (21 chapters). III.—Properties of and Methods for Testing Molten Iron—Phenomena in the Actions of Cooling Metal, etc.—Results of Tests in All Kinds of Irons—Best Methods for Testing (23 chapters). APPENDIX. Selected Tables for Use in Furnace and Foundry Work.

Cloth 638 Pages 153 Illustrations Price, $3.00 net

Sent Anywhere, postpaid, for the Price by the

McGRAW PUBLISHING COMPANY

114 Liberty Street :: New York

and elementary statement of the fundamental conceptions of Maxwell's theory of electromagnetism. No. 3 deals with the second principle of thermodynamics, entropy being defined as the degree of probability of the distribution of different forms of energy. No. 4 is the famous address presented by Boltzmann as rector of the University of Graz in memory of Gustav Robert Kirchhoff. If anybody has ever been able to explain in words why mathematics is an art and how a mathematical paper may be beautiful, Boltzmann has succeeded in doing so in this address by means of analogies between the working methods of the musician and of the mathematical physicist. No. 5 is a brief discourse on the importance of theories or of pure theory. No. 6 deals with problems of aeronautics, No. 7 is the address held at the unveiling of the monument in memory of Josef Stefan.

Nos. 8 and 9 are papers dissecting critically and caustically the methods of modern "energetics," *i. e.*, the new thermodynamical school of Ostwald and others. Boltzmann shows first that in the field of mechanics the methods of energetics have been almost absolutely barren of results. He then analyzes the methods of energetics in thermodynamics, and finally goes on record with respect to some points brought out in Ostwald's well-known lecture on scientific materialism. Boltzmann emphasizes that he considers those men against whom he speaks here to be his personal friends, and that he considers their work in other fields but energetics as of greatest importance. But he sees a great danger in the advance of energetics. "Quite often young men now enter the field of energetics which promises easy results, while they have not the necessary mathematical training and judgment required for successful work in theoretical physics." Every chemist who might be tempted to become an amateur in energetics should read this chapter of Boltzmann. In Nos. 10 and 11 Boltzmann endeavors to show why physics cannot get along without the atomic theory. No. 12 is a critical discussion of the question of the objective reality of the phenomena in lifeless nature.

No. 13 is a brief elementary discussion of Roentgen rays. No. 14 is a lecture giving an historical review of the development of the methods of theoretical physics in recent times and of the different schools. No. 15 is an account of the life and work of Josef Loschmidt. No. 16 gives the four lectures held by Boltzmann in 1899 at Clark University, on the fundamental principles and fundamental equations of mechanics, No. 17 two further general lectures on the principles of mechanics, while No. 18 is the first of a series of lectures held by Boltzmann on "Naturphilosophie." No. 19 is Boltzmann's lecture held at the Scientific Congress in St. Louis on statistical mechanics. No. 20 shows Boltzmann again in a controversy with Ostwald, with respect to the latter's theory of happiness; in the first part Boltzmann is searcastic, and his aim is to make fun of the theory in question; later on he gets bitter in earnest.

No. 21 is a review of W. Vaubel's handbook of theoretical chemistry, No. 22 a critical discussion of Schopenhauer's philosophical system. The concluding article, No. 23, is the story of Boltzmann's trip to California, where he lectured at Berkeley. Of all articles in the book this one comes nearest the title popular writings. The story is written in a very amusing style, and in his sarcasms Boltzmann does not even spare himself. He fully appreciates the beauties of California. "We may gather as much delight and happiness as there is room for in a human breast on a trip through the mountains of our fatherland. We may be as satisfied as a king at a simple meal. But a trip to California is champagne Veuve Clicquot and oysters." But this story also reveals Boltzmann's limitations, those of his stomach and those of the man. What he tells about the breakfast in Mrs. Hearst's house and especially about oatmeal, simply shows that even a man like Boltzmann may not resist the temptation to talk about things he does not understand. And it is a little doubtful if some parts of the story are in good taste. Taken as a whole, the book is, however, a delightful human document worthy of its author.

Electrochemical and Metallurgical Industry

VOL. V. NEW YORK, AUGUST, 1907. No. 8.

Electrochemical and Metallurgical Industry

With which is Incorporated Iron and Steel Magazine

Published on the first of each month by the
ELECTROCHEMICAL PUBLISHING COMPANY,
[Incorporated.]
114-118 LIBERTY STREET, NEW YORK.

J. W. RICHARDS, PH. D. ..... *President*
E. F. ROEBER, PH. D. ..... *Editor and Secretary*
C. E. WHITTLESEY ..... *Treasurer*

Subscription Price: $2 per year, postpaid to any part of the world. Single copies 25 cents.

Copyrighted, 1907, by the Electrochemical Publishing Co.

Entered as Second-Class Matter, June, 1903, at the Post-Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, AUGUST, 1907.

CONTENTS.

EDITORIAL 297
The Metal Market in the Hot Months 297
New Zinc Works 297
Electric Heat Versus Heat from Fuel 298
Symbolism of Chemical Equations 298
American Electrochemical Society 300
The Iron and Steel Market 300
CORRESPONDENCE:
The Townsend Cell for Sodium Chloride Electrolysis. By L. H. Baekeland 301
The Gayley Dry Blast Process. By Oskar Nagel 302
Pyritic Smelting. By Robert Sticht 302
Ontario Meeting of the American Institute of Mining Engineers 303
Metallurgical Calculations. (Pyritic Smelting). By J. W. Richards 304
A Burner for Cutting Metals. By M. U. Schoop 308
Electrolytic Refining of Tin. By Otto Steiner 309
The Iron and Steel Institute Meeting 312
Electrolytic Refining of Bismuth. By Arnold Mohn 314
NOTES ON ELECTROCHEMISTRY AND METALLURGY IN GREAT BRITAIN 315
SYNOPSIS OF CURRENT PERIODICAL LITERATURE 318
ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS 321
RECENT METALLURGICAL PATENTS 327
Lead-Lined Hose 331
Cold Galvanizing 331
Hard-Lead Exhaust Fans 333
Automatic Still 334
NOTES 334
DIGEST OF UNITED STATES PATENTS. (Calcium Carbide) 336
NEW BOOKS 337
BOOK REVIEWS:
A. H. Allen's Commercial Organic Analysis 337
A. S. McAllister's Alternating-Current Motors 337
O. P. Watt's Silicides and Borides 338
W. Pick's Ferrosilicium 340

The Metal Markets In the Hot Months.

The metal markets at the opening of the second half of the year do not exhibit the strength and buoyancy this year that they had in 1905 and in 1906. Nor is this so surprising. For the past year we have seen an increase in price as well as in production. These were conjointly caused by an increased consumption. Now it is obvious that consumption cannot long keep increasing at an increasing rate, for this would force prices to so high a level that consumption would be automatically cut off. This is precisely what has happened to some degree in the past six months and accounts for the sagging metal markets. For instance, our net exports of copper are now practically nil. Another allied reason is that there is not enough capital to pay for new construction when labor and supplies are more than a third higher than in 1904. As there is at any one time a fixed amount of capital the increase of cost of supplies by such a practice has diminished the "availability" of capital by just such a fraction. The easing off of the prices of all metals is a sign of a healthy reaction, of a return to a more stable and equitable basis for industry. While 25-cent copper would not make us all pay 10 cents for trolley fare, it would, nevertheless, restrict the number of new electric railroads and retard the electrification of trunk lines of existing steam railroads which have a high density of traffic. There is plenty of money in mining with copper at 15 cents, lead at 5.5 cents, spelter at 6 cents, and pig iron at $15. Higher prices for a long period would cause eventually a restriction of consumption and an expansion of production so great as to cause a bad depression in the metal business when the bubble was pierced.

New Zinc Works.

Conditions in the zinc business point to a large increase in the smelting capacity of the spelter works of the United States. Things usually operate in cycles, and Newton's law of mutual reactions is as true in industry as in physics. The year 1905 we saw a great excess of smelting capacity over ore production. Consequently zinc ore, especially from the Joplin field, was at a premium. The average price for "Joplin 60 per cent concentrates" showed during that year with the average price of spelter at St. Louis a margin of profit only for those plants operated very efficiently as regards recovery and treatment costs. Some of the zinc companies also made money by carrying large tonnages of metal over to the late fall, when the price for spelter was higher. In 1906, however, the pendulum started to swing back and the margin for the smelting operation increased rapidly from nothing to $8 or $10 per ton at the end of the year. The consumption of the metal increased so greatly and the importation of ore from Mexico was so large that even several abandoned plants using coal were put in operation. New plants using natural gas as fuel were also started.

This movement of building new plants kept on at an accelerating pace until the present day, when there are four large gas plants partially built (with one in operation) and nearly as many new coal plants in the Illinois field either in partial operation or in course of construction. As a result of this the smelting capacity of the zinc plants of the country will be nominally increased by the end of the year about 25 per cent, and probably 35 per cent by next Spring. However, as it takes time to start a new spelter works the movement in ore prices will be gradual. But the inception of the movement is seen to-day. There are always delays in the shipment of materials, due to railway congestion, and many other causes retard the erection of plants. Furthermore, the supply of workmen trained to labor about a zinc furnace is limited. But making all allowances for these several factors, it cannot be doubted that there will be a large excess of smelting capacity over ore production in the near future. Consequently, the price of Joplin ore is likely to rise to those limits made by metallurgical and commercial conditions of little or no profit to the average zinc plant. While the production of Joplin, Wisconsin, and Rocky Mountains increases, and importations from Australia, Algeria and Mexico will further augment the ore supply, these factors are not great enough to fill the increased demand.

* * *

As it takes time to develop mines and erect concentrating plants, it will be not before the close of 1908 that the smelters have easier conditions, to say nothing of a harvest similar to that of 1906. In the meantime, it would look as if there would be greater profit in the treatment of low-grade ores, sulphides analyzing 35 per cent zinc and carbonates analyzing 30 per cent zinc, for only a few of the plants care at present to treat ores of so low grade of ore. With a high degree of metallurgical efficiency and with the lessened demand for poorer ore, a works would have a nice margin on the so-called "Western" ores, when Joplin prices were prohibitive. In addition, these ores are so cheap that large amounts of them can be stocked without tying up much capital. The market for the metal continues strong, even with increased production. The fact that 60 per cent of the consumption goes into the steel trade, which is exceptionally healthy in tone, gives basic elements of strength to the market. Indeed, we should be surprised if spelter sold for the remainder of the year at less than 6 cents a pound on the average. The increase in the interest in zinc mines and the number of zinc plants now being built show that this fascinating, volatile and flirtatious metal will occupy a more important place on the metallurgical stage in the future than in the past.

Electric Heat Versus Heat From Fuel.

In the Synopsis of Current Literature in our present issue we notice the last reports of our San Francisco contemporary, *The Mining and Scientific Press*, on the progress of the Noble Electric Steel Co.'s work at Héroult-on-the-Pitt, in Shasta County, Cal. As will be remembered from our former notices this undertaking of Mr. H. H. Noble is noteworthy in two respects from an industrial point of view. If successful it will mark the beginning of commercial manufacture of pig iron at the Pacific Coast, and at the same time it is the first commercial plant in the world in which the electric furnace enters into competition with the blast furnace. A concise analysis of the possibilities of electric heat versus heat from fuel seems timely, and it seems proper to first view the problem from the narrow point of view which is most unfavorable to the electric furnace and which simply inquires as to those relative costs of fuel and electrical energy for which the cost of the blast-furnace and of the electric-furnace treatments becomes the same. The immense importance of the element carbon in metallurgy is due to its double application as a strong reducing agent and as a fuel to produce, by its oxidation, the heat needed for the chemical reaction. In the case of reduction of iron from the ore, the blast furnace and the electric furnace require the same quantity of carbon to act as reducing agent and to combine with the oxygen in the iron oxide. But the blast furnace also requires carbon for producing the necessary high temperature, and it is only this last portion of carbon, the calorific value of which is replaced by electrical energy in the electric furnace. We will, therefore, first compare the cost of fuel and electrical energy to produce the same number of heat units.

* * *

One kilowatt-hour is equivalent to 860 kilogram-calories, which is approximately the full heat obtained from 100 grams of good coal when completely burnt to carbon dioxide. If the cost of a ton of coal of 2,000 pounds (or 907 kilograms) is a dollars, and if the efficiency of heat production by burning coal is x per cent, then the coal required for producing 860 kilogram-calories costs $a \div 90.7\ x$ dollars. On the other hand, if the cost of 1 kilowatt-hour is b cents and if the efficiency of producing heat from electrical energy is y per cent, then the kilowatt-hours, required for producing 860 kilogram-calories, cost $b \div y$ dollars. Hence electrical heat will be cheaper than heat produced by combustion of fuel if $a\ y$ is greater than $90.7\ b\ x$. To go further, we need the efficiency figures x and y. By assuming definite figures we introduce, of course, an uncertainty into our comparison, but it will probably be considered fair if for a first approximation we assume a 25 per cent efficiency for fuel heating and a 75 per cent efficiency for the electric furnace. Then we conclude that electrical heat will be cheaper than heat produced from fuel if a is greater than $30.2\ b$, or in words, if the cost of a ton of coal in dollars is more than 30 times the cost of a kilowatt-hour in cents. For instance, to compete with coal at $6.00 per ton, the electric kilowatt-hour would have to cost less than 0.2 cent. This is clear evidence that if the electric furnace did not have other important features it could not compete with fuel heat under ordinary conditions.

* * *

We have purposely made this comparison on the basis of the cost of the ton of coal and of the kilowatt-hour, although it has become customary to use the electric horsepower-year as the unit of electrical energy in such estimates. Then the above condition can be stated in this way: electric heat will be cheaper than fuel heat if the cost of 1 ton of coal is more than one-half the cost of the electric horsepower-year. Stated in this form, the comparison looks more favorable for the electric furnace than stated, as in the preceding paragraph. But in

reality it is not proper to make the comparison on the basis of the horsepower-year, since we thereby implicitly assume that the electric furnace is working continuously every hour all year around, which is in general a decidedly improper assumption.

* * *

It is, of course, clear that the above comparison is exceedingly narrow in that it considers only one single side of the problem, namely, the amount of fuel and electrical energy required to produce the same number of calories. But even in this very respect the above comparison falls short of the truth and does not do justice to the electric furnace. The chief reason is that electrical heating is essentially internal heating, permitting a very high concentration of energy at any point wanted and thus enabling one to produce high temperatures. Fuel heating, on the other hand, is always more or less transmission of heat from the fuel to the charge, and the rate of heat transmission depends on the difference of the two temperatures; this rate decreases rapidly the higher we go up in the temperature. Naturally, with fuel heating we can never obtain any higher temperature than that of the burning fuel itself. There is no corresponding limitation in electric heating. This is the fundamental reason why for all very high temperature processes the electric furnace reigns supreme. This is an established fact, but since electric reduction of iron ore does not fall into this class of processes, we may not further discuss them here, except by pointing out that the possibility of obtaining higher temperatures might be found useful for special cases of iron ores; for instance, with titaniferous slags. It is of greater importance perhaps to refer to the fact established at the Sault Ste Marie experiments that iron ores containing a high sulphur contact can be successfully smelted in the electric furnace so as to get a pig iron containing only a few thousandths of 1 per cent of sulphur. Through the electric furnace certain iron ores will therefore become available for the production of pig iron which heretofore could not be treated economically. This will probably become more important in future years than it seems to be at present.

* * *

But there is another point. With respect to the reducing agent it was stated above that the same amount of carbon as reducing agent is required in the electric furnace as in the blast furnace to rob a certain amount of iron oxide of its oxygen. This is perfectly true, but it would be absolutely wrong to conclude that the electric furnace has therefore no advantage in this respect over the blast furnace. The point is that the blast furnace requires coke, while charcoal or peat coke will do very well in the electric furnace. This point is at the bottom of the whole situation in California. On account of coke not being available, California has not had its own pig iron industry. At the new plant on the Pitt River there is unlimited timber for charcoal making. Viewed from every point the undertaking of Mr. Noble looks promising, especially if we consider that pig iron sells in San Francisco at about $10.00 more than in Pittsburg. Let us hope that the work which was officially inaugurated on our national holiday, the Fourth of July, will turn out commercially successful. It would be a matter of great industrial importance for California and would stimulate similar progressive work in other districts where the conditions appear sufficiently favorable for electric smelting and sufficiently different from the conditions in our present blast furnace centers. In the latter centers electric smelting for reduction of iron from ore is, of course, out of question.

Symbolism of Chemical Equations.

For the average engineer who has not made a specialty of chemistry, the significance of a chemical equation is restricted; it simply indicates to him the relative weights of the different substances involved in the reaction. This is something, but it is by no means everything, since every chemical equation has a much wider significance. In a journal devoted to engineering it seems not improper to say a few words concerning the different ways in which a chemical equation may be interpreted. Different interpretations mean different points of view. The equation is mathematically always the same, but according to the key or the dictionary which we apply, the equation reveals a different view of the reaction for which it stands. The dictionary which we apply to find the relative weights of the different substances is the table of atomic weights. But if any of the substances taking place in the reaction is in the gaseous state and we know the pressure and temperature, we can also find directly the volume from the equation; for this we need as key the constant of Avogadro's rule, 22.42, *i. e.*, the number of cubic meters filled by 1 kilogram-molecule of gas at atmospheric pressure and at 0° C. The same key opens the field of solutions, at least of those solutions for which van't Hoff's theory of the parallelism between gaseous pressure and osmotic pressure in solutions holds good.

* * *

Further, to enter an entirely different field, if the equation involves oxidation and reduction it can represent an electrolytic process. If it does, we find directly from the equation the relation between the quantity of electricity (coulombs or amperehours) and the weights of the substances transformed; we need as key the constant of Faraday's law 96,540, *i. e.*, the charge in coulombs of a monovalent gramion. But the symbols in a chemical equation may also be considered as masses endowed with energy; then the ordinary equation does not balance; but with the aid of thermochemical tables as dictionary, we find the heat-balance sheet or energy-balance sheet of the reaction. If in case of an electrolytic process we want to apply Thomson's rule for a first approximation, we get from the energy-balance sheet directly the voltage of the reaction; the key is here 0.000434, that is the figure with which we have to multiply the gram-calories, involved in a gramatomic monovalent change, to get the volts. Finally, if we want to get the capacity of the reaction for performing work we find it from the equation by means of a free-energy table as dictionary, and from this we can find the exact e. m. f. with the same key which is used in Thomson's rule. The importance of tables of physical and chemical constants is thus manifest: they are just as necessary for the engineer as the dictionary is for making a translation into another language. The universal value of the work of men like Berthelot, who has spent almost a lifetime for the determination of thermochemical data, cannot be overestimated. Nevertheless, much still remains to be done even in this field. Far more remains to be done in the determination of the "free energies" of reactions.

American Electrochemical Society.

At a meeting of the Board of Directors, held in Philadelphia on July 31, the following gentlemen were elected members of the Society: Mr. Franz Roessler, manufacturing chemist (Roessler & Hasslacher Chemical Co.), Perth Amboy, N. J.; Dr. Eugene Haanel, Director of Mines, Department of Mines, Ottawa, Can.; Mr. L. D. Vorce, superintendent Pennsylvania Salt Manufacturing Co., Wyandotte, Mich.; Prof. Herschel C. Parker, Columbia University, New York City; Dr. John W. Brown, Director Research and Battery Laboratory, National Carbon Co., Cleveland, Ohio, and Mr. J. G. Kremers, general superintendent Wisconsin Sugar Co., Milwaukee, Wis..

At the preceding meeting of the Board of Directors several vacancies on the board had been filled by electing Prof. S. A. Tucker, of Columbia University; Mr. F. A. J. FitzGerald, of Niagara Falls, and Mr. F. J. Tone, of Niagara Falls, managers of the Society.

The next meeting of the Society will be held this Autumn in New York City, probably early in October. The New York Section of the Society will be in charge of the arrangements, but the president of the Society, Prof. C. F. Burgess, of the University of Wisconsin, who is at present in the East, also spends very considerable time and efforts to make the coming meeting very attractive. The dates of the meeting will probably be either Oct. 3 to 5 or 10 to 12.

The Iron and Steel Market.

July has been an extremely dull month in all branches of the iron and steel trade. There has been scarcely any new business, and that chiefly for early delivery. A dull midsummer is the rule rather than the exception in the trade, but the last two years furnished exceptions, so that the contrast is rather striking.

In a period devoid of very interesting developments the most important has been the relative firmness which has been maintained despite the dullness. In finished steel products there have been no recessions in price; in pig iron the chief change has been the sudden and complete disappearance of premiums for early delivery, while prices for late deliveries have sagged very slightly. Specifications on old contracts have continued to come in fairly well, and postponement has been asked on the shipment of comparatively little material.

The future of the market is necessarily in doubt. Periods of dullness like this usually hatch out changes, if any are at all likely to come at any time. The mills and furnaces entered the dullness with order books very well filled, and have readily been able to maintain shipments up to their capacity, which is somewhat decreased in the hot weather. They can, as a rule, run for two or three months yet without any decided buying movement. Production of pig iron during the first half of the year was about 13,500,000 gross tons, against 13,700,000 tons in the second half of last year and 13,600,000 tons in the first half of last year. With new furnaces lately completed and others to be completed shortly, production in the second half of this year could reach about 14,500,000 tons, or at an annual rate 2,000,000 tons in excess of that in the first half. Imports of ordinary grades of pig iron have been discontinued; nevertheless, to maintain the pace, consumptive demand in the second half would have to exceed that of the first half by more than a million tons a year. All prospects are that it will be decreased rather than increased. Pig iron is in a sensitive position, prices having advanced to a level quite out of line with finished products. It is hard to see, therefore, how pig iron prices can fail to undergo a material recession. Theoretically they could drop several dollars a ton without endangering the price structure on finished material, because, as just noted, they have been out of line with finished material, but time and again the iron trade has shown that this theory does not work out in practice. With prices of finished material stationary, an advance and a subsequent decline in pig iron always dislodges the price structure of finished material ultimately.

July 15 a strike was inaugurated of dock laborers at the ore docks at Duluth and Two Harbors. The following week the men at the Superior docks came out, thus completely tying up all the docks at the head of the lakes, which are the outlet for all the Mesaba and Vermillion range ores except the relatively small tonnage which goes out on all-rail routes. At the same time many of the miners on the Mesaba range, suddenly organized by the Western Federation of Miners, went out. As all these men had individual contracts the employers refused to make concessions. The Menominee, Gogebic and Marquette rangers, with the docks serving them, are not affected. Some efforts have been made to create the impression that this strike has a greater influence upon the iron trade than is really the case. At this writing the matter is not settled, but it can be said that all computations of loss of ore tonnage—and whatever is lost in dock movement is practically lost to the season, as the mines can hardly accumulate much ore—are based upon the assumption that it was necessary to the iron trade to bring down all the ore which physical conditions in the chain of mining and transportation would permit. A decision to that effect may have been reached before the season opened, but conditions have since changed, and it is now far from certain that any very large gain over last season's movement is necessary. The movement to July 15 indicated that a gain of 6,000,000 tons or more could be made over last season's total of 38,500,000 tons, and this strike could be prolonged for a month or more and still permit a moderate gain over last season, which would probably be sufficient.

Pig Iron.

Premiums for prompt pig iron have totally disappeared. In general deliveries are well taken, but in occasional instances consumers have asked for some delay in deliveries, and in still rarer instances there is complaint that furnaces are trying to ship more than the contract tonnage. This has resulted in an ample supply of prompt iron. There has been a slight decline in quotations for delivery in the fourth quarter, and all deliveries are on a parity, about as follows: f. o. b. Mahoning or Shenango Valley furnace (90 cents higher delivered Pittsburg); Bessemer, $22.50; basic, $22.00; No. 2 foundry, $22.50; forge, $21.75 to $22.00.

Steel.

The United States Steel Corporation continues short of steel, the Carnegie Steel Company still being much behind in deliveries on its outside billet obligations. The steel corporation bought over 50,000 tons of open-hearth and Bessemer billets during the second quarter, and purchases have continued through July. The steel has been applied largely on outside billet contracts, but doubtless the purchases would not have been made with such avidity had there not been danger that the open market would decline to a point below the settlement price on sliding scale contracts which are controlled by the average price of pig iron. Some outside interests can readily sell crude steel; one such interest in July sold 500 tons of Bessemer billets and completed shipment three days after the placing of the order. We quote Bessemer billets, delivered Pittsburg, at $30.00 and open-hearth at $31.50 to $32.00. Sheet bars remain at $31.00, f. o. b. Pittsburg.

Rails.

Placing of important rail contracts is still delayed by the discussion over specifications. The most interesting development is the disclosure that the improvements quietly undertaken at the Edgar Thomson rail mill of the Carnegie Steel Co. involve the casting of ingots of double the cross-section employed for years, making 4-ton instead of 2-ton ingots, and the erection of a heavy stand of rolls to precede the present blooming mill to take care of the larger section. At the same

time a change in methods will be made whereby the ingots will not be allowed to cool so suddenly between the converting department and the soaking pit. It is confidently expected that these changes will make sounder steel and reduce the length of the pipe. Demand for light rails continues good.

Finished Material.

Altogether, contracts for steel for ten lake boats, to be built next season, have been taken by the Carnegie Steel Co., and several others are under negotiation. Many semi-annual contracts with jobbers for plates, shapes and bars have been renewed by the mills. Outside of this business new buying has been very light, but as stated, the mills have ample tonnage on books to carry them for two or three months yet.

Prices of finished steel products are unchanged, and are as follows, f. o. b. Pittsburg:

Structural shapes, $1.70 per hundred pounds for beams and channels, 15 inches and under.

Plates, $1.70 for tank quality.

Merchant steel bars, $1.60, base.

Common iron bars, $1.70, delivered Pittsburg, and $1.60, f. o. b. Pittsburg, for Western delivery.

Sheets, 28 gauge, $2.60 for black and $3.75 for galvanized.

Tin plates, $3.90 for 100-pound cokes.

CORRESPONDENCE

The Townsend Cell for Sodium Chloride Electrolysis.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—In your last issue you published a letter by Mr. J. R. Crocker, which expresses astonishment and doubt as to the extraordinarily high efficiencies of the Townsend cell. Your correspondent cannot be more astonished than I myself and others were when for the first time we witnessed the unusual performance of this remarkable cell.

Just because results were so unexpectedly high special pains were taken to insure great correctness in the methods employed for determining efficiencies. Observations were continued for months in succession day and night; very perfect ammeters and voltmeters were selected, and the instruments were frequently verified; furthermore, analytical methods were checked by independent observers. For calculation of energy efficiencies we, of course, used the very method described by Mr. Crocker, taking the factor 2.29—or in round numbers 2.3—as figured by the Thomson or thermochemical rule, this being the hypothetical lowest voltage for the decomposition of sodium chloride solutions.

I would respectfully suggest to Mr. Crocker to carefully reread the article which astonishes him so much and he will find that nowhere is there any mention of energy efficiencies as high as 68 per cent, so this requires no further answer.

But energy efficiencies of 55 per cent to 60 per cent are quite high enough; yet such efficiencies are not unusual with the Townsend cell, although they quite naturally excite wonder and surprise to all whose experience has been with other forms of electrolytic cells.

The Townsend cell can be run with quite a strong load on voltages as low as 3.3 to 3.4 volt or even lower, but it has been found more expedient and economical to sacrifice energy efficiency to *capacity* and to run at much higher loads, which, of course, will increase the voltage. But even running at 1 amp. per square inch the voltage remains as low as 4 to 5 volts. This is due to the fact that the distance between anode and cathode scarcely exceeds three-eighths of an inch.

There seems to be somewhere some confusion in the statements of Mr. Crocker where he speaks of the voltage of the curve in Fig. 7, which is the record of a defective cell, and substitutes this voltage instead of the much lower voltage of a normal cell, as described in Fig. 6. I take this opportunity for correcting a serious omission of a footnote under Fig. 6, which has occurred in the printing of the report of my paper: It will be noticed that at some points of the curve the indicated ampere-hour efficiency goes above 100 per cent; this seeming impossibility is easily explained by the fact that in the Townsend cell the liberated sodium metal accumulates upon the surface of the cathode plate, forming a sort of alloy with iron; once in a while this accumulated metal reacts upon the liquid, forming sodium hydroxide. Whenever it occurs the stored up alkali metal increases suddenly the output of sodium hydroxide, and at that moment the efficiency curve may be too high. During the period immediately following, the efficiency curve will be correspondingly too low, but averages will come quite close to 100 per cent. A very convincing confirmation of these high efficiencies was made by the repeated analysis of the chlorine gas, which always showed nearly 100 per cent pure, whenever the ampere-hour efficiencies approached the latter number. Furthermore, the amount of HClO and $HClO_3$ in the anode liquor averaged as low as 100 milligrams per liter.

These records relate to commercial cells of full size, but run separately with good care. Under such conditions, whenever the ampere-hour efficiency sank below 97 per cent, we knew that something was wrong, and after correcting the conditions we were always able to increase the efficiency to about 100 per cent.

In practice, however, where cells are run in sets of about sixty and where conditions are not so favorable and things

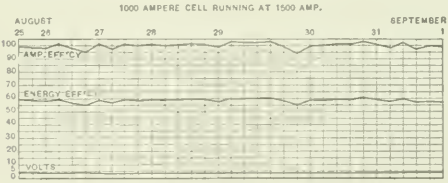


FIG. 6.—EFFICIENCY CURVES.
(Reproduced from page 210 of June issue.)

have to be run rather roughly, a few defective cells may show a depressing influence on the whole system and lower somewhat efficiencies; but even then average ampere-hour efficiencies of 90 per cent are considered very poor work although the current densities were about 1 amp. per square inch of active anode surface. Under good practical conditions, using no special care, 95 per cent to 97 per cent ampere-hour efficiencies are considered normal averages. I know that this statement will astonish many persons who heretofore have considered 90 per cent ampere-hour efficiency very good for other types of cells, although the latter are run at considerably smaller loads.

I ought to mention that lately some disturbance has been caused at the Niagara Falls plant owing to some defective rubber shield insulators, and this has considerably upset the regular operation of the cells; yet under these abnormally defective conditions the average ampere-hour efficiencies have seldom dropped below 90 per cent to 93 per cent. This little trouble is being done away with and will be entirely prevented in the future by a slight modification in this detail of the construction of the cells; the latest reports are 97 per cent average ampere-hour efficiencies for 62 cells.

In answer to the last remark concerning the salt which is carried by the cathode liquor, I desire to state that the amount of salt can be regulated within satisfactory limits by modifying the hydrostatic pressure. Furthermore, the elimination of the salt is an easy operation, as soon as the solution is submitted to evaporation the salt is precipitated, not only by evaporation but also by the fact that sodium chloride becomes insoluble in concentrated solutions of sodium hydroxide.

I believe Mr. Crocker is mistaken if he thinks that the main corrosive action on steel tubes in vacuum pans is due to the presence of salt. Were it so it would not be practical to manufacture table salt in vacuum pans, yet this method is extensively employed. The corrosive action of cathode liquor occurs mainly when strong caustic lyes are evaporated, and for that reason it has been the practice here and abroad to finish evaporation of strong caustic liquors in cast iron finishing kettles.

L. H. Baekeland.

Yonkers-on-Hudson, N. Y.

The Gayley Dry-Blast Process.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—While traveling in Continental Europe a few months ago, I had several interviews with some prominent iron masters, and I naturally was interested to learn what they think about the Gayley process.

The general impression about this system on the other side is that it does not and will not effect a reasonable saving, *i. e.*, a saving that will pay more than the ordinary interest on the investment. Otherwise, the European iron works would be the first to adopt this system, since the economical conditions over there necessitate the greatest possible economy, especially with respect to raw material, which is high-priced in Europe as compared to America.

If the Gayley process would effect a saving it would have a much greater value (comparatively) in Europe than in America, the cost of the raw materials being a much greater item over there than here. In this country the cost of *labor* is of greatest importance, in Europe the cost of the *raw materials*. Hence, a material saving process which is successful in America will be still more successful in Europe, while a labor-saving process which is successful in Europe will be still more successful in America.

I was informed that in certain iron works the most careful observations and researches have been made, for several years, relative to the influence of the moisture of the air upon the iron output. In some of the iron works the difference of temperature in the summer and winter amounts to 40° C. But even with this great difference practically no increase of the iron output in winter as compared to the summer output was observed. The argument is that since a decrease of 40° C. in temperature means a corresponding decrease of the air moisture, an increase of the yield of the furnace should have been observed, if the Gayley process is to be a success.

Reliable detailed data on the saving effected by the Gailey process would certainly be highly appreciated by iron and steel men.

Oskar Nagel.

New York City.

[From the manner in which the Gayley process has been received in Europe, and especially in Germany, in the technical press as well as in meetings of engineering societies, it would seem that our European friends approach the problem by way of speculating a priori as to what results they may expect from dry blast. In spite of its ingenuity this speculative method which has been so characteristic of certain renowned systems of metaphysics, due to German philosophers, involves great dangers when applied to new engineering problems. In speculating a priori, that is from the cause to the effect, one is liable to overlook that one single cause, the effect of which is to be determined, is often intimately connected with other causes which are also effective. The only proper way to discuss the Gayley process is to take the exact data of its operation in plants where it is used on an industrial scale, and to analyze these figures so as to deduce the causes from the results. This method, which avoids all dangers of speculation and simply analyzes the facts, has been applied to a set of figures of Mr. Gayley by Dr. J. W. Richards, our Vol. III., p. 240. But, of course, such an analysis requires very full experimental data, and we join our correspondent in the hope that full reliable data on the working of the Gayley process—in addition to those already given by Mr. Gayley and Mr. Meissner—will soon be available. We await with special interest the results of the Pottstown plant, to which we referred on page 290 of our last issue. It would also be very interesting if those European iron masters who have observed the influence of moisture of air upon the iron output during a series of years would publish their figures.—Editor.]

Pyritic Smelting.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—In the "Synopsis of Periodical Literature" of the Electrochemical and Metallurgical Industry of February last, there is a reference, on page 59, to our smelting process here, in which data derived from an article of mine in Borchers' "Metallurgie" of 1906 are compounded with others taken from a paper read by Mr. R. Nicholls before the Chemical, Metallurgical and Mining Society of South Africa. I am not acquainted with the latter paper, but the information given by Mr. Nicholls is evidently greatly obsolete, in some respects, and positively erroneous in others. There are grave contradictions between Mr. Nicholls and myself. Now, these disparities are not of professional interest to me personally, but they may mystify some of your American readers who may take a deeper interest in the subject matter, because, unfortunately, your reviewer erroneously alludes to Mr. Nicholls as a "late assistant manager of the works," thus tacitly ascribing to Mr. Nicholls the possession of a full acquaintance with the subject of his paper in its latest phases.

In view of the share which my own writings have had in the compilation of Prof. Peters' "Principles of Copper Smelting," the unfortunate intrusion of Mr. Nicholls in the guise of a presumptive sharer of my experiences, but with a discrepant presentation of same, is likely to give rise to a puzzled condition of mind as to who is right and who is wrong. For the sake of such readers I beg to state that Mr. Nicholls left the Mount Lyell Co.'s employ for South Africa some four or five years ago, after having filled the position of junior assistant in the chemical laboratory. Prior to his departure his experience in connection with our smelting method was practically nil, or, to be fairer to him, his acquaintance with it was restricted to such facts, of a general nature, as a young man in his position had the opportunity of gathering from observation. It is evidently these crumbs of information that he has written up in South Africa, in itself a sufficiently laudable action, but hampered, in this instance, by inaccuracies on the one hand and on the other by a serious neglect of the circumstance that things did not, since his departure, remain standing at the point where he thought he saw them while here.

I might also, perhaps, take this opportunity of referring to your reviewer's reference (page 31 of your January issue) to a supposed omission on my part, in Borchers'."Metallurgie" of Nov. 8, of the heat of slag formation during the union of ferrous oxide and silica, as if this elementary fact were unknown to me. I had, however, no reason whatever for mentioning it. Your reviewer has evidently not grasped the purport of my simply casual reference to the circumstance that the amount of iron present in the particular sulphide which does the work in the pyrite furnace evolves a greater amount of heat than does the sulphur accompanying it. It cannot be said that whatever additional heat the subsequent union of ferrous oxide and silica may contribute, such increment is due to the burning of the iron. The fact is that the heat of slag formation may with equal justice be ascribed to the silicon, which is no part of the compound originally acting as the fuel, as to the ferrous oxide.

Robert Sticht.

General Manager, Mt. Lyell Mining & Railway Co., Ltd.
Queenstown, Tasmania.

Ontario Meeting of the American Institute of Mining Engineers.

The Ontario meeting of the American Institute of Mining Engineers was held July 23 to 30, opening on the 23d in Toronto. The headquarters were in the palatial King Edward Hotel, the opening session being on the afternoon of Tuesday, the 23d, in the banquet hall of the hotel. The address of Dr. Douglas, on "Some Reflections on Secrecy in the Arts," was the feature of this session, and it is needless to advise those who know Dr. Douglas how he handled this subject and cauterized the ultra-secretive and foolishly shortsighted policy of some individuals and corporations.

The reception in the evening at the Parliament Buildings was a revelation to most of the visitors. The rich splendor of the edifice, combined with the formal and dignified tone given to the occasion, gave the impression of being 3,000 miles away from the United States instead of nearly within sight of our shores. Some of the engineers are said to have whispered to their intimates that the occasion would have been more enjoyable if it had been not quite so stiff. However, the warmth of Canadian hospitality and good friendship beat beneath the courtly bearing and medal-covered breasts of the Institute's hosts, and the oftner the scene is recollected the pleasanter becomes its memory.

Wednesday, the 24th, morning and afternoon, were given over to reading and discussion of papers. The indispensable secretary of the Institute (everybody knows his name) was indefatigable in stirring up discussion and giving point and piquancy to the proceedings. A splendid oil painting of Dr. Raymond, by the way, stood in one corner against the wall, and smiled benignantly on the assemblage, so that even when the Doctor was out of the room his spirit seemed to contemplate and participate in the proceedings. The painting was presented by some one to somebody else, but everybody seemed to know its resting place and its object; it will ornament the Institute's quarters in the Engineering Building, and will there continue for many centuries, let us hope, to dispense the benediction of the Doctor's genial smile and to prolong his memory and his influence in the Institute.

By common consent the paper of the day was Mr Saunders' account of the electric air rock drill. To be a mining engineer you have to drill and be drilled, and therefore the subject interested everybody. But the conclusion, announced so positively by Mr. Saunders, that compared with the ordinary air drill the power consumption was *halved*, took the meeting by surprise. How tremendously important, if it is true was the universal sentiment, coupled with the corallary, but it is true, since Mr. Saunders says it

At 8 P. M. the members of the Institute who could spare the time boarded the special train provided by the liberality of the government, bound for Cobalt, while those who could not go regretfully turned their faces homeward.

* * *

We are afraid some of our Canadian friends are looking for results from this excursion of a kind not to be expected from it. A leading journal informed its readers that Cobalt (also Sudbury, etc.) was going to be *investigated* by the Institute that on their return they would give their *verdict*, and the exact truth about these regions would be given to the world, thus putting an end to all uncertainty about the value of these deposits, the mines, mining stock, etc., of these regions. All this is purely visionary; no such result can come from the visit; the engineers are on a pleasure trip, they will incidentally give many hints and suggestions we have no doubt, to their Canadian *confreres*, and on their return they will think and act more intelligently than they could have done before in regard to these Canadian enterprises, but they are not going to investigate or settle definitely any such questions as the newspaper misled its readers into believing. The trip will do Canada a healthy lot of good, but there will be something left for many an investigating committee after the engineers are all back home from their trip.

* * *

The program of the trip to the Cobalt district includes visits of Cobalt, New Liskeard, Haileybury, Temagami, with excursions to various mines and trips on the Lake Temiskaming and the Lake Temagami. The veins which have made the area known throughout the mining world were discovered during the building of the Temiskaming & Northern Ontario Railway in the late summer of 1903. The first public announcement of the discovery of the camp was made in November, 1903. In September, 1904, the railway from North Bay had been completed, and the shipments from the camp by the end of the year amounted to 158 tons, valued at $136,217, an average of $862 per ton. The values of the shipments during 1905 and 1906 are shown in the following table:

	1905,		1906,	
	Quantity.	Value.	Quantity.	Value.
Silver, ounces	2,473,452	$1,372,577	5,357,830	$3,543,089
Cobalt, tons	118	100,000	312	30,819
Nickel, tons	75	10,000	156	.....
Arsenic	549	2,693	1,558	.....
Total	.....	$1,485,570	.....	.....

The shipments for 1907 to July 15 amount to about 7,000 tons. The statistics as to value are not complete.

After the visit to the Cobalt district the program provides a trip to Sudbury, the Creighton Mine, the Copper Cliff works of the Canadian Copper Co., the Moose Mountain iron mine and the Vermilion placer deposits.

The Sudbury district is the world's greatest producer of nickel, and the mines and smelting works are equipped with modern machinery.

* * *

The following is the complete list of papers read or taken as read at the meeting:

Some Reflections on Secrecy in the Arts, by James Douglas.

The Wilfley Table, by R. H. Richards.

The Tar Sands of the Athabaska District, by Robert Bell.

The Occurrence of Nickel in Virginia, by Thomas L. Watson.

Condition of the Coal-Briquetting Industry of the United States, by E. W. Parker.

The Temple-Ingersoll Electric Air Rock Drill, by W. L. Saunders.

Notes on (*a*) the Cobalt Mineral Area, by Willet G. Miller; (*b*) the Sudbury Mineral Area, by Alfred E. Barlow (illustrated with lantern views)

Geology of the Virginia Barite Deposits, by Thomas L. Watson.

The Effect of High Litharge in the Crucible Assay for Silver, by Richard W. Lodge

Physical Factors in the Metallurgical Reduction of Zinc Oxide, by Woolsey McA. Johnson

Zinc Oxide in Iron Ores and the Effect of Zinc in the Iron Blast Furnace, by John J. Porter.

Chronology of Lead Mining in the United States, by Walter R. Ingalls

The Promontorio Mine, by Francis C. Lincoln.

Blow-Holes in Steel Ingots, by E. von Maltitz

The Evergreen Copper Deposit, by Etienne A. Ritter

Pure Coal as a Basis for the Comparison of Bituminous Coals, by W. F. Wheeler.

Quantitative Field Test for Magnesia Cement Rock and Limestone, by Charles Catlett.

The Production of Converter Matte from Copper Concentrates by Pot Roasting and Smelting, by George A. Packard

The Panoramic Camera Applied to Photo-Topographic Work, by Chas. W. Wright

Notes on the Present Source and Uses of Vanadium, by J. Kent Smith

The Mines of San Juan Depomuceno del Doctor, by T. D. Murphy.

Metallurgical Calculations.

By J. W. Richards, Ph. D.

Professor of Metallurgy in Lehigh University.

Pyritic Smelting.

This method of smelting is sometimes called pyrite smelting, because usually practiced on ores rich in pyrite; it is, however, just as applicable to ores rich in pyrrhotite (magnetic pyrites) or chalcopyrite (copper pyrites), and therefore the more general term *pyritic* smelting is really the more proper and descriptive of the range of the process.

For a full description of pyritic smelting we would refer the reader to the volume "Pyrite Smelting,"[1] a symposium of information contributed by nearly forty metallurgists, and edited by T. A. Rickard or to Sticht's monograph, "Ueber das Wesen des Pyrit Schmelzverfahrens,"[2] or to Dr. Peter's "Principles of Copper Smelting,"[3] which contains a 125-page chapter upon it.

A brief statement of the principles of the process is as follows: Given an ore containing considerable silica in the free state and a good percentage of pyrite, pyrrhotite or chalcopyrite, it is possible to smelt it down in a shaft furnace to a ferrous silicate slag and a matte by means of cold blast and without using any carbonaceous fuel. Whether fuel is cheap or dear the possibility of dispensing with it when smelting down certain sulphide ores is highly important; yet it is only within a very few years that the principles involved have been well enough understod to make the process a recognized success. As far as *modus operandi* is concerned, the ore is charged into a shaft furnace, water-jacketed at the boshes and smelting zone, with enough flux to furnish 10 to 20 per cent of CaO or similar alkaline earth base to the slag, and a high pressure of blast is employed, such as would correspond to a high rate of driving in ordinary smelting (up to 3½ pounds pressure per square inch is used). The matte and slag either collect in the well of the furnace or run continuously into an external settler, where they separate as in ordinary smelting. The heat necessary to run the furnace is all supplied by the oxidation of sulphur and iron in the furnace, the former escaping as SO^2 in the gases and the latter as silicate of FeO in the slag. The process may be regarded as a very quick partial roasting of the ore, accompanied by simultaneous formation of melted slag and matte, because of the high temperature generated by the oxidation itself.

There is hardly any process in the whole of metallurgy which invites so strongly to quantitative calculations, such as we are endeavoring to encourage by these articles; and there are fewer processes which present such a lack of data upon which to base the calculations. Not only are the physical and chemical (thermochemical) data scarce, but the ordinary industrial data, careful details of the running of the furnaces, weights and compositions of charges and products, analyses and temperature of gases, are very largely lacking—most that we have of value are those furnished as recently as 1906 by Robert Sticht, director of the Mount Lyell furnaces in Tasmania, and these apply only to his particular furnaces and operations.

Fundamental Principles.

Taking the simplest case, and supposing FeS^2 and SiO^2 to be charged into a pyritic smelting furnace, we know without a doubt that the FeS^2 becomes approximately FeS at a red heat, and the sulphur thus evolved is driven off at a part of the furnace where there is no free oxygen, so remains in the furnace gases as sulphur vapor. At a temperature of 1 300° Sticht has shown experimentally that the FeS becomes something like Fe^7S^8, and it is known that the sulphur in the matte is often less than can correspond to FeS. But the actual temperature of combustion attained at the moment of oxidation in pyritic smelting is higher even than 1,400°, and it is almost certain that as FeS oxidizes, it is heated so intensely that it really goes through two stages, first decomposing to Fe^2S and then oxidizing to FeO:

$$2FeS = Fe^2S + S$$
$$Fe^2S + SiO^2 + 2O^2 = SO^2 + 2FeO.\ SiO^2$$

or, putting it all together:

$$2FeS + SiO^2 + 2O^2 = S + SO^2 + 2FeO.\ SiO^2$$

If we cast up the thermochemistry of this reaction we find a very considerable evolution of heat, easily comparable with the heat of oxidation of carbon, and accounting for the running of the furnace. The thermochemical analysis of the above reaction is:

		Calories.
Absorbed.		
Decomposition of 2FeS		48,000
Evolved.		
Formation of 2FeO	= 131,400	
" " SO^2	= 69,260	
" " $2FeO.\ SiO^2$	= 8,900	
		209,560
Excess of heat evolved =		161,560

The FeS and SiO^2 come into the zone of oxidation already heated to a high temperature by their contact with the rising hot gases. They come to this zone, or focus, heated to at least 1,000°, and perhaps hotter, before they begin themselves to oxidize. The air comes in cool, and we will not credit it with any sensible heat at the moment oxidation begins.

Theoretical Temperature at the Focus.

With these data, and a few reasonable assumptions, we can calculate how hot the focus will become at its hottest point. This calculation is similar to that for the calorific intensity of combustion of a fuel, or the theoretical temperature before the tuyeres of a blast furnace. Making the calculation for the quantities represented by the equation, and assuming

Heat in FeS at 1000° melted	200 Calories.
" " SiO^2 at 1000° solid	260 "
" " Slag ($\frac{5}{8}$ weight of FeO) : $0.27\ (t - 1100) + 300$	"
" " Matte ($\frac{3}{8}$ weight of slag) : $0.14\ (t - 1000) + 200$	"

We can calculate the theoretical temperature t, to which the slag, matte and gases will be raised by the heat at hand, which latter is the sensible heat in FeS and SiO^2 at, say, 1,000°, plus the heat evolved in the reaction.

	Calories.
Heat in 2FeS at 1000° : 176×200	= 35,200
" " SiO^2 at 1000° : 60×260	= 15,600
" of the reaction	= 161,560
Total heat available =	212,360

Calorific capacity of the products:

SO^2	$= 22.22(0.36t + 0.0003t^2)$
N^2	$= 170(0.303t + 0.000027t^2)$
Slag	$= 240[300 + (t - 1100)0.27]$
Matte	$= 80[200 + (t - 1000)0.14]$
Sum	$= 0.0113t^2 + 135.5t + 5,520 = 212,360$

Whence $t = 1429°$ C.

The result of our calculation is to show that a temperature sufficient to run the furnace is theoretically obtainable if the weight of slag made, carrying a given weight of FeO, is not too great. Supposing the silica and other slag-forming ingredients are so heavy in comparison to the amount of FeO formed by

[1] Engineering and Mining Journal, New York, 1905.
[2] Wilhelm Knapp, Halle, 1906. Reprinted from "Metallurgie."
[3] Hill Publishing Company, New York, 1907.

oxidation that the slag contains only 50 per cent of such FeO, then the weight of slag above would be 288 instead of 240, and the temperature attained only 1,324° instead of 1,429°. This reduction, however, is getting perilously near the temperature necessary to keep the furnace in operation. The formation temperatures of copper blast-furnace slags are 1,100° to 1,200°, and an over-heating of at least 50° is necessary for practical operation of the furnace. Suppose we put 1,200° as the minimum theoretical temperature which will run the furnace, then the maximum weight of slag can be calculated in the above solution for t, and thence the minimum percentage of FeO.

Let X be the maximum weight of slag, for t a minimum of 1,200°. Then we have:

	Calories
Heat in SO^2 at 1200°	= 19,248
" " N^2 at 1200°	= 68,422
" " Slag at 1200°	= 330X
" " Matte at 1200°	= 18,240
Whence	$105,940 + 330X = 212,360$
and	$X = 323$ kg.

Since this maximum weight of slag must contain the 2FeO = 144 kg. of FeO, the minimum percentage of FeO produced by oxidation and going into slag in pure pyritic smelting, must be

$$144 \div 323 = 0.45 = 45 \text{ per cent.}$$

The margin for working pyritic smelting is ordinarily so small that variations in the temperature of the blast and its humidity must exercise a large influence on the running of the furnace. This coincides with experience as far as the heating of the blast is concerned. At La Lustre Smelter, Santa Maria del Oro, Mr. Koch says that "a warm blast of 200° C. is a *sine qua non* with us: it spelled success; cold blast meant failure." This is, however, an extreme position; many other metallurgists working other ores have run entirely with cold blast, but there is no doubt that smelting is easier, faster and more regular when using warm blast. No one has yet tried drying the blast, but there can be no doubt that under some circumstances this would contribute greatly to the regularity of running and would increase the theoretical temperature obtainable at the focus or smelting zone.

Use of Auxiliary Coke.

When the amount of slag-forming materials in the charge is high, pyritic smelting using cold, ordinary blast may become impossible for lack of sufficient calories to melt the slag and matte. In this case, which often occurs, some coke may be used, the combustion of which to CO^2 at the focus increases materially the heat available and the temperature. If the temperature desired is, let us say, 1,400°, carbon at 1,000° can burn to CO^2, yielding CO^2 and N^2 as products, and give a large surplus of heat to the charge at this temperature.

One kilogram of coke, containing 0.9 kg. of carbon, will form 3.3 kg. of CO^2 (1.67 cubic meters) and 6.35 cubic meters of N^2. The heat generated is 7,290, and adding in the heat in hot carbon at 1,000° (342) we have 7,632 Calories generated. But in the products at 1,400° we have:

	Calories.
CO^2 $1.67[0.37 + 0.00022(1400)] \times 1400$	= 1582
N^2 $6.35[0.303 + 0.000027(1400)] \times 1400$	= 3038
	4620

Surplus, to help the fusion

$$7632 - 4620 = 3012 \text{ Calories.}$$

Each kilogram of coke used will therefore melt down, at 1400°,

$$3012 \div 330 = 9 \text{ kg.}$$

of slag, and thus relieves the situation materially. At Mount Lyell, 0.5, 1.0 and 1.5 per cent of coke (reckoned on the charge) is found necessary, according to the nature of the ore worked. From this we have increasing quantities of coke used up to several per cent, according to the exigencies of the case and we pass by insensible gradations through partial pyritic smelting to ordinary smelting. As the carbon is increased the sulphides get less and less of the oxygen blown in, and therefore the degree of oxidation of sulphides is lower and the concentration poorer. The best concentration, using unroasted sulphide ore, is obtained by pure pyritic smelting, if there are enough sulphides present to generate the requisite heat and temperature.

Rate of Smelting.

In all that precedes it has been assumed that the furnace was driven fast enough. Other things being equal, the harder a furnace is blown the more material can be put through it, and the smaller the heat losses by radiation and conduction when expressed per unit of charge treated or of product obtained. It is, therefore, possible to increase the temperature in the focus simply by harder blowing, and thus to decrease the amount of auxiliary coke needed. A similar effect is produced by heightening the furnace shaft, since this increases the regeneration of heat by the charges, they coming to the hot zone more intensely preheated by the ascending gases. The present tendency in pyritic smelting is undoubtedly to increase the rate of driving, heighten the furnace, and thus decrease the auxiliary coke needed and dispense with hot blast, which is somewhat of a complication.

The possibility of smelting in any manner depends on being able to generate the theoretical temperature necessary for running the furnace, and then keeping the rate of smelting per minute per unit area of the smelting zone as high as practicable. This achieves two practical results, viz.: makes the actual temperature of melted-down slag and matte approximate closer to the theoretical temperature of the focus, and gets the largest tonnage through the furnace. As we gradually increase the smelting rate we increase the temperature of the focus, because of decreased radiation losses; but, on the other hand, we tend to decrease the relative amount of oxidation, because of the decreased time that the charge is subjected to oxidation; there must be a certain rate of driving which will attain the maximum of oxidation, i. e., of concentration, and past which increased tonnage is put through at the cost of decreased concentration.

Problem 107.

W. H. Freeland (*Engineering and Mining Journal*, May 2, 1903), at Isabella, Tenn., smelted Ducktown pyrrhotite ore in a water-jacketed Herreshoff furnace, having a cross-sectional area at the tuyeres of 21.7 square feet. The analyses of the materials used and the products is as follows:

	Charges			
	Ore	*Quartz*	*Slag*	*Coke*
Cu	2.744	.....	0.73	.....
Fe	36.519	1.45	39.20	2.30
S	24.848	0.32	1.75	1.58
SiO^2	18.548	96.79	30.90	8.41
CaO	7.204	0.23	8.51	.....
MgO	2.672	.....	2.71	.....
Zn	2.556	....	2.88	....
Al^2O^3	0.911	.32	1.90	3.56
Mn	0.770	....	0.85	.....
O	...	0.38	11.37	1.00
C	...	...	...	83.86
CO^2	3.138	...	...	...
Loss	...	0.30	...	...

	Products.		
	Matte	*Flue Dust*	*Slag*
Cu	20.00	2.20	0.37
Fe	47.15	30.80	38.81
S	23.00	16.51	1.74
SiO^2	0.44	23.92	32.60
CaO	0.10	4.45	8.24
MgO	.....	1.38	3.44
Zn	2.05	2.98	1.54

AlO^3	0.82	1.94	1.50
Mn	0.53	0.15	0.80
O	4.01	15.26	10.88

The charges and products per 24 hours and per 1,000 of ore used were:

Charges:		
Ore	68.0 tons	1000 lbs.
Quartz	5.4 "	80 "
Slag	9.8 "	145 "
Coke	2.3 "	34 "
Products:		
Matte	8.34 tons	122.65 lbs.
Flue dust	1.75 "	25.71 "
Slag	63.81 "	938.24 "

Blast applied, 4,500 cubic feet displacement per minute, at 17-ounce pressure. Assume temperature of gases 450° C., and that they contain no CO, SO^3 or free O^2 (no analyses are given). Assume matte and slag issuing from the furnace at 1,300° (no temperature given).

Required

(1) A balance sheet of everything entering and leaving the furnace.

(2) The volume efficiency of the blowing plant.

(3) The heat generated per minute, per square foot of cross-section, in the focus of the furnace.

(4) The theoretical temperature at the focus.

(5) The proportion of the heat generated in the focus by the combustion of carbon and by the oxidation of sulphides.

(6) If hot blast were used what should be its temperature to be able to dispense with the coke charged? Assume that the pressure was increased so as to keep the delivery to the furnace constant per minute.

Per 1000 of Ore Smelted.

Charges.		*Matte.*	*Flue Dust.*	*Slag.*	*Gases.*
Ore (1.000).					
Cu	27.44	24.53	0.57	2.34	.....
Fe	365.19	57.83	7.92	299.44	.....
S	248.48	29.44	4.24	16.33	198.47
SiO^2	185.48	0.54	6.15	178.79	.....
CaO	72.94	0.12	1.14	71.68	.....
MgO	26.72	.....	0.35	26.37	.....
Zn	25.56	2.51	0.77	22.28	.....
Al^2O^3	9.11	1.00	0.50	7.61	.....
Mn	7.70	0.64	0.14	6.92	.....
CO^2	31.38	.....	.....	.....	31.38
Quartz (80).					
Fe	1.16	.....	.....	1.16	.....
S	0.26	.....	.....	.....	0.26
SiO^2	77.43	.....	.....	77.43	.....
CaO	0.18	.....	.....	0.18	.....
Al^2O^3	0.26	.....	.....	0.26	.....
H^2O	0.71	.....	.....	.....	0.71
Slags (145).					
Cu	1.06	.....	.....	1.06	.....
Fe	56.84	.....	.....	56.84	.....
S	2.54	.....	.....	.....	2.54
SiO^2	44.81	.....	.....	44.81	.....
CaO	12.34	.....	.....	12.34	.....
MgO	3.93	.....	.....	3.93	.....
Zn	4.18	.....	.....	4.18	.....
Al^2O^3	2.76	.....	.....	2.76	.....
Mn	1.23	.....	.....	1.23	.....
O	15.31	6.04	3.93	5.34	.....
Coke (34).					
Fe	0.78	.....	.....	0.78	.....
S	0.54	.....	.....	.....	0.54
SiO^2	2.86	.....	.....	2.86	.....
C	28.51	.....	.....	.....	28.51
Al^2O^3	1.21	.....	.....	1.21	.....
O	0.10	.....	.....	0.10	.....
Blast (1,191).					
O^2	274.91	.....	.....	97.92	176.99
N^2	916.37	.....	.....	.....	916.37
	2450	122.65	25.71	946.16	1355.77

Notes on the Balance Sheet.

The oxygen of the blast goes as SO^2 and CO^2 into the gases and as oxides into the slag. The amount required for the gases is

$$\text{O in } SO^2 = S \times \frac{32}{32} = 100.96$$

$$\text{O in } CO^2 = C \times \frac{32}{12} = 76.03$$

$$176.99$$

$$\text{O for Fe} = 330.68 \times \frac{16}{56} = 94.48$$

$$\text{O for Zn} = 26.46 \times \frac{16}{65} = 6.51$$

$$\text{O for Mn} = 8.15 \times \frac{16}{55} = 2.37$$

O in slag = 103.36

Contributed by charges = 5.44

Contributed by blast = 97.92

To burn sulphides and carbon at the Focus = 176.09

Total from blast = 274.91

(2) The furnace receives 1,191 pounds of blast per 1,000 of ore smelted. This represents at 0° C.:

$$\frac{1191 \times 16}{1.293} = 14{,}738 \text{ cubic feet.}$$

Per 2000 lbs. ore	= 29,475 " "	
Per 68 tons ore	= 2,004,300 " "	per day
	= 83,510 " "	" hour.
	= 1,400 " "	" minute.
At 50° C.	= 1,477 " "	" "
Blower displacement	= 4,500 " "	" "

$$\text{Efficiency of blower} = \frac{1{,}477}{4{,}500} = 0.328 = \mathbf{32.8} \text{ per cent.} \quad (2)$$

[It is high time that practical furnace men should stop giving the mechanical displacement of their blower as the amount of air received by their furnace. They still keep doing that, although the furnace receives only from 85 per cent down to 25 per cent of the given volume. What per cent of the piston displacement the furnace is actually receiving is a highly important datum, but is more often unknown than known to the practical men. It can usually only be found by calculation, as is illustrated in the preceding case. We urge upon practical furnace managers, for their own information and use, to cease being satisfied with *piston displacement*, and to get deeper into the real inwardness of their furnace processes by calculating the *air actually received* by their furnaces. The two things are enough different to make it always "worth while."]

(3) To calculate the heat generated at the focus we will assume that all the fixed carbon of the coke is there burned to CO^2, and that the rest of the oxygen blown in produces the reaction characteristic of pure pyritic smelting. We have treated per minute

$$\frac{68 \times 2000}{1440} = 94.4 \text{ lbs. of ore.}$$

and the carbon burned per 1000 of ore is 28.51, generating

$$28.51 \times 8100 = 230{,}930 \text{ lb. Calories.}$$

this absorbs

$$28.51 \times 8/3 = 76.03 \text{ lbs. of oxygen}$$

leaving $274.91 - 76.03 = 198.88$ lbs. of oxygen to oxidize sulphides.

Since, now, $2O^2$ generates by the pyritic smelting reaction 161,500 calories, we have generated per pound of oxygen thus used:

$$161{,}560 \div 64 = 2{,}524 \text{ lb. Calories.}$$

and per 1000 of ore smelted we will have

$$2{,}524 \times 198.88 = 502{,}000 \text{ lb. Calories.}$$

total heat generated

$$502{,}000 + 230{,}930 = 732{,}930 \text{ lb. Calories.}$$

Since this is per 1000 of ore smelted, per minute we have

$$732{,}930 \div 1000 \times 94.4 = 77{,}640 \text{ lb. Calories.}$$

and per square foot of smelting zone area

$$77{,}640 \div 21.7 = \mathbf{3{,}575} \text{ lb. Calories.} \qquad (3)$$

This last figure is extremely useful in determining the relative activity of different furnaces, and in most cases will be a reliable index of the rate at which the furnace is capable of being driven.

(4) Taking as the basis of calculation 1,000 pounds of ore smelted, there is generated at the focus 732,930 pound Calories, there is used 1,191 pounds of blast, and there arrives at the focus all of the charges except the flue dust, CO^2 of ore, H^2O of quartz, and approximately one-quarter of the sulphur. We, therefore, have arriving at the focus about

28.51 lbs of fixed carbon.
526.50 lbs. of sulphides.
621.20 lbs. of inert slag-forming material.

These, assuming them to reach the focus at 1,000°, would bring back into it the following amounts of heat:

Carbon	$28.51 \times 380 =$	10,834 lb. Calories.
Sulphides, melted	$526.50 \times 200 =$	105,300 " "
Slag-forming material	$621.20 \times 174 =$	108,089 " "
		224,223 " "
Heat generated at the Focus		732,930 " "
Total heat available at the Focus		= 957,153 " "

Letting t be the theoretical temperature at the focus, then we have

Heat in Slag $946[300 + (t - 1100)0.27]$
" " Matte $123[200 + (t - 1000)0.14]$
" " S vapor $76[179 + (t - 445)0.11]$
" " SO^2 $35[0.36t + 0.0003t^2]$
" " CO^2 $53[0.37t + 0.00022t^2]$
" " N^2 $727[0.303t + 0.000027t^2]$.

[The 76 pounds of sulphur vaporized at the focus is the total sulphur charged, less the 25 pounds assumed as volorized above the focus, and less the 100.96 pounds oxidized at the focus; the expression is the total heat in 1 pound of sulphur vapor at t in pound-Calories. The 70 of SO^2 is the weight of sulphur dioxide formed, in pounds, divided by 288, the 53 of CO^2 is the weight of CO^2 formed, in pounds, divided by 1.98; the 727 of N^2 is the weight of N^2 divided by 1.26. To be strictly logical, the weights of SO^2, CO^2 and N^2 should be first multiplied by 16 to get ounces, and the resulting expression in ounce-calories divided by 16 to get pound-Calories. We have simply dispensed with these two numerical operations.]

The sum of the calorific capacity of the products at t is

$$20{,}098 + 530.5t + 0.0425t^2 = 957{,}153$$

whence $$t = \mathbf{1569}^\circ \qquad (4)$$

It will be noted that the temperature is nearly higher than could have been attained by attempting to smelt this mixture without coke. If the coke were omitted from the charge we would be without the 28.51 pounds of fixed carbon and some 5.5 pounds of slag forming material; the products would be without the CO^2 and the N^2 corresponding to it, and the heat available would be decreased 230,930 pound Calories from the absence of carbon. If these corrections are made, and it is still assumed that the materials come down into the smelting zone at 1,000°, the theoretically calculated temperature is

$$t = \mathbf{1447}^\circ$$

While this temperature is theoretically sufficient, yet variations in ore quality and temperature and humidity of the air would make running under these conditions much more precarious than with the coke.

(5) This has already been calculated. We found 230,930 pound-Calories to be due to the formation of CO^2 and 502,000 to the oxidation of sulphides, making of the total

31 per cent. from oxidation of carbon
69 per cent. from oxidation of sulphides. (5)

(6) If coke were dispensed with, the theoretical temperature previously attained, 1,569°, might be reached if the air used were heated. With cold blast we have under (4) calculated a theoretical temperature of 1,447°. Under these conditions the heat available was altogether 725,266 pound Calories. But to heat the products, whose heat capacity was

$$20{,}083 + 451.7t + 0.0247t^2$$

to $t = 1{,}569°$ would require (evaluating) 789,600 pound Calories, which is 64,334 pound Calories more than are available. To supply this difference by heating the blast we reckon first the amount of blast per 1 000 of ore smelted, which will be 862 pounds and its heat capacity:

$$\frac{862}{1.293}(0.303t + 0.000027t^2)$$

making this equal to the heat to be supplied, 64,334 lb. Cal. we have

$$202t + 0.01805t^2 = 64{,}334$$

whence $$t = \mathbf{313}^\circ. \qquad (6)$$

Problem 108.

At Mount Lyell, Tasmania, R. Sticht analyzed the gases at different depths of the shaft in a pyritic smelting furnace, and found them of nearly uniform composition for 6 feet down, leaving out the sulphur vapor, which condensed in taking the samples. At 6 to 7 feet below the top, close to the focus of the furnace, the mean of 5 analysis gave by volume

H^2	0.00
SO^3	0.00
SO^2	7.90
CO^2	3.56
CO	0.00
O^2	0.88
N^2 (difference)	87.66

The CO^2 comes from coke, which it was stated was used to the extent of 1.5 per cent of the charge. The slag contained 53 per cent FeO, 30 per cent SiO^2.

Required:

(1) The percentage of the heat generated in the furnace coming from the oxidation of sulphides and the combustion of carbon.

(2) The heat developed in the furnace per unit of slag formed.

(3) The volume of blast per 1,000 kg. of slag formed.

Solution:

(1) We will assume the reaction of oxidation of sulphides to be

$$FeS + 2O^2 = SO^2 + 2FeO$$

and, in fact, the above analyses are our chief justification for so doing. The air blown in is approximately 20.8 per cent of oxygen by volume, and according to the above equation the oxygen going to form FeO is equal to that going to form SO^2. We have then for the oxygen used

O^2 to form 7.90 SO^2	7.90
O^2 to form — FeO	7.90
O^2 to form 3.56 CO^2	3.56
O^2 to form 0.88 O^2	0.88
Sum	20.24

$$O^2 \text{ corresponding to } N^2\ 87.66 \times \frac{20.8}{79.2} = 23.00$$

There is thus a small deficit of oxygen, but if the sulphide oxidizing were assumed to be FeS the reaction would be

$$2FeS + 3O^2 = 2SO^2 + 2FeO$$

And the oxygen accounted for from the gases would be only

O^2 to form 7.00 SO^2	7.00
O^2 to form 6 FeO	3.05
O^2 to form 3.56 CO^2	3.56
O^2 to form 0.88 O^2	0.88
	16.29

Which barely accounts for two-thirds of the oxygen which must have accompanied the nitrogen.

The conclusion must therefore be that the sulphide which is being oxidized is Fe^2S, and not FeS, for otherwise the gas analyses would show impossible conditions.

The oxidation of the sulphides gives for each O^2 thus used 161,500 ÷ 2 = 80,780 Calories, and the oxidation of C to CO^2 97,200. From the above analyses we infer that for 3.56 volumes of oxygen used for CO^2 15.80 volumes were used in oxidizing sulphides. The relative amounts of heat thus generated are therefore:

By carbon 97,200 × 3.56 = 346,000 = **21.3** per cent.
By sulphides 80,780 × 15.80 = 1,276,300 = **78.7** " " (1)

(2) The production by oxidation of 2FeO (144 kilograms) is accompanied by the production of SO^2 (64 kilograms) and the evolution of 161,500 Calories. The slag being 53 per cent FeO, the slag formed by the reaction is 144 ÷ 0.53 = 272 kg. The 64 kg. of SO^2 would be, in volume, 22.22 cubic meters, and would be accompanied in the gases by

$$22.22 \times \frac{3.56}{7.00} = 10 \text{ m}^3 \text{ of } CO^2.$$

which contains 10 × 0.54 = 5.4 kg. of C.
whose heat of oxidation to CO^2 is
5.4 × 8100 = 43,740 Cal.
but, heat from sulphides = 161,560 "

total heat available 205,300 "
per kg. of slag 205,300 ÷ 272 = **755** Cal. (2)

Per unit weight of charge this heat would be slightly lower.

(3) The oxygen used per 272 kg. of slag is

for SO^2	22.22 m^3
" FeO	22.22 "
" CO^2	10.00 "
Total	54.44 "
per kg. of slag	0.20 "
" 1000 kg. of slag	200. "

Volume of air per 1000 kg. of slag made
200 ÷ 0.208 = **960** cubic meters (3)

The Ohio Copper Co., which was incorporated in Maine a few days ago, and which F. Augustus Heinze of the United Copper Company is to head, was formed to take over the Ohio group of mines in Bingham, Utah, which for some time have been under the control and management of Mr. Heinze, and in which large ore bodies already have been developed. A 4,000-ton mill is being built to concentrate these ores and the first section will be completed in November. It will treat 2,000 tons a day. The second section should be ready by next May. In connection with Mr. Heinze's Utah mining operations it is stated that his Salt Lake representatives already have secured title to a site for his proposed 3,000-ton smelting plant which is to be built by the Miners' Smelting Co. The new smelter will be located about 2 miles west of the old Garfield bathing resort at the south end of the Great Salt Lake.

A Burner for Cutting Metals.

By M. U. Schoop.

A well-known physical experiment is the burning of a white-hot iron wire in pure oxygen, yielding a pyrotechnical effect due to finely-divided iron oxide being thrown off in all directions. An application of this phenomenon—for cutting metals—has, however, been made only during the past few years after success had been obtained in welding iron, copper and other metals autogenously with the oxygen flame, so that iron may be joined directly with iron, copper with copper, etc., without using any foreign metal.

An analogous case is the electrolysis of water which has been known as a laboratory experiment for the past hundred years, but has become of industrial importance only during the last ten years—at least in Continental Europe, where there are now a number of systems which are in use on an industrial scale.

In principle, a burner for cutting metal consists of an ordinary oxygen-acetylene or oxygen-illuminating gas or oxygen-hydrogen burner, such as used for autogenous welding of metals provided with an additional small tube for *separately* supplying oxygen gas for cutting. If, for instance, an iron or steel plate, 1 inch thick, is to be cut by means of such a burner, the plate is preheated with the normal welding flame up to white heat along the line where it is to be cut, and then a strong oxygen gas current is directed along this line. Under the action of the oxygen the autogenous burning of the iron starts immediately.

Since the oxygen supply may easily be directed on any distinct point, as is evident from the sketch, Fig. 1, the burning of the metal is restricted to those points where the oxygen comes in contact with the plate. The "melting line," or cutting line, has a diameter of only a few millimeters with sharp edges.

It makes no difference whether thin or thick iron plates (up to 20 mm.) are to be cut. Of course, with thicker material a correspondingly greater burner is to be used. It also makes no difference whether the hydrogen-oxygen flame is used, or the illuminating gas-oxygen flame, or the acetylene-oxygen flame, or the benzine-oxygen flame.

The least expensive is the acetylene-oxygen flame, especially when thick plates are to be cut, since this gas mixture evolves the greatest number of calories per unit of gas volume. In some cases in practice, however, illuminating gas or benzine may be used instead of gas or acetylene for the sake of convenience.

With respect to the effect the hydrogen-oxygen, illuminating gas-oxygen, benzine-oxygen flames are about equivalent, although, of course, different types of burners must be used for the different gas mixtures[1]. Especially if illuminating gas or

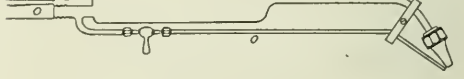


FIG. 1.—BURNER FOR CUTTING METAL.

benzine is used the burner is to be designed according to the suction principle, so that the oxygen gas passing out quickly through the hole sucks the other gas with it. These "injector burners" are advantageously used in all those cases in which two gases are employed of which one is under high pressure (oxygen) and the other under low pressure (benzine or illuminating gas).

To return now to the method of cutting metals by means of such a burner I will summarize the precautions which must be taken.

---

[1] See also the book of the author Die Industrielle Electrolyse des Wassers (Enke, Stuttgart) and La soudure autogène des Métaux (P. Dusmenil, Paris).

First. The piece of metal to be cut must be placed on two suitable supports in such a way that the melting metal is not prevented from dropping down.

Second. The pressure of the supplementary oxygen-gas supply must be higher the thicker the material to be cut.

Third. The metal to be cut is first heated with the ordinary melting flame and must be brought up to white heat before the separate oxygen-gas current is turned on. The burner should be used as quietly and uniformly as possible and the quicker the thinner the metal to be cut.

Fourth. If one wants to get a very nice and straight cutting line it is useful to make use of a ruler.

Fifth. The burner must be held in such a way that the supplementary oxygen-gas tube almost touches the metallic surface; only under these conditions a pretty sharp cut can be obtained.

As Fig. 1 shows it is not necessary to employ a separate oxygen bomb for the supplementary oxygen-gas tube.

There is no question that such cutting burners may be used to great advantage in many cases in metal industries. On the other hand I must mention one great disadvantage of this apparatus, namely, the possibility of opening by its means within a few minutes the largest "fireproof" safe. This fact should be taken into consideration by manufacturers of safes.

Paris, France.

Electrolytic Refining of Tin.

By Otto Steiner, Ph. D.

Historical.

While most metals are now being electrolytically refined tin represents an exception. The reason is that in dressing tin ores they are purified to such a degree that the smelting process yields directly very pure tin which does not need any further refining. The small quantities of impure tin which are placed on the market and which have a greater content of foreign metals contain very small amounts of precious metals (½ to 1 per cent Ag). They are used to good advantage for the preparation of alloys.

The first attempt to refine tin electrolytically on a large scale was made by the firm of A. Strauss & Co., in London, in the year 1905, in their smelting works, the Penpoll Tin Smelting Co., Bootle. The process used was invented by Mr Claus[1], and was somewhat modified by me. About a hundred tons of 90 per cent raw tin were refined, and the product was tin of 99.9 per cent purity.

According to the method of Claus, tin alloys are electrolyzed in a 10 per cent sodium sulphide solution at a temperature of 90° C., with a current density of ½ amp. per square decimeter electrode surface at a voltage below 0.2 volt. Tin is stated to be deposited on the cathode in a pure condition, while the foreign metals (Pb, Sb Cu, Fe, Bi, Ag, etc.) are precipitated as sulphides and form the anode slimes mostly attached to the anode but partly accumulating on the bottom of the tank.

Theoretical.

If a solution of sulphide of sodium is electrolyzed between two tin electrodes, sulphur is set free at the anode and forms tin sulphide, which dissolves in the electrolyte. The sodium ions are discharged at the cathode, and with a sufficiently high voltage the sodium would react with the surrounding water, forming caustic soda and hydrogen, according to the equation $Na_2 + 2H_2O = 2NaOH + H_2$. This would involve the evolution of hydrogen gas; but since the voltage is kept below 0.2 volt no hydrogen gas can be set free, as the voltage is less than the "Haftintensität" of the hydrogen ion. Therefore, the sodium[2] cannot react with the water, but reacts with the surrounding sulphide of tin according to the equation $2Na_2 + SnS_2 = 2Na_2S + Sn$, so that tin is deposited on the cathode and sulphide of sodium regenerated[2].

In this way tin is continuously dissolved and Na_2S consumed at the anode and tin is deposited, and Na_2S is continuously regenerated at the cathode. Since the Na_2S formed at the cathode does not at once mix with the electrolyte, but may be seen to flow down the cathode in streams (Schlieren), care must be taken to mix the electrolyte thoroughly. This is best accomplished by heating the bath from below.

The electrolysis takes place without development of gas, if the voltage at the terminals is kept below 0.2 volt. But as soon as this tension is exceeded, even by a small amount, by increasing the current density or by diminishing the concentration of sodium sulphide in the solution, it rises suddenly and automatically up to 0.6 volt, and violent generation of gas with decomposition of the electrolyte takes place. At the same time the cathodic deposit becomes dull, spongy and contains oxides. But it is in practice of great importance to get dense coherent metallic tin on the cathode, since spongy tin cannot be directly melted and cannot be treated without losses in the furnace.

To obtain always compact, metallic tin deposits, I have found that besides the temperature of the electrolyte, its thorough mixing and the maintenance of a low voltage, the following five conditions are of importance:

(1) Only pure tin plates or tin plated plates must be used as cathodes. Tin deposits on other metals like iron, copper, etc., in spongy form with generation of gas and increase of the tension till up to 2 volts. This is due to the chemical reactions of these metals with the electrolyte ($Fe + Na_2S = FeS + 2NaOH + H_2$) and to the higher potential difference between the changed metals and the electrolyte.

(2) No foreign metals like Fe, Cu, Sb, etc., should be pressed in the electrolyte, either suspended or dissolved or in form of a colloid. These metals have in alkaline solution a lower positive potential than tin, and consequently they are deposited before tin on the cathode surface, which is rendered thereby unsuitable to receive a dense tin deposit. Cathodes which have been spoiled in this way must be removed and replaced by new tin cathodes with bright metallic surface, in order to get good tin deposits. On the other hand, the deposition of the foreign metals before the tin has the advantage that the electrolyte is purified. It may thus be kept in good condition for months so that it is only necessary to add from time to time some sulphide of sodium to keep the original concentration of 10 per cent Na_2S constant. In order to avoid completely the suspension of foreign metals in the electrolyte, it is advantageous to carry out the electrolysis in such a way that the anode slime on the bottom of the bath and that attached to the anodes is not disturbed. Any violent movement of the electrolyte must therefore be avoided.

A circulation of the solution such as used in the electrolytic refining of copper, is impossible for tin refining. Every tank must be operated independently, and is only in electric connection with the other tanks.

If, for example, after completed electrolysis the electrodes are to be taken out, it is first necessary to allow the solution to flow off very slowly through a syphon-like pipe, the end of which is slightly above the bottom of the cell and above the slime layer; after that the electrodes, and finally the anode slime are removed. The new electrodes may then be inserted and the clear and, if necessary, filtered solution is run into the cell.

(3) Before suspending new tin anodes with metallic surfaces in cell, it is necesary to dissolve in the electrolyte about 1 per cent of its weight of sulphur, preferably in form of

[1] Engl. patent No. 297, year 1895.

[2] The electrolysis can also be explained in another way as follows: The SnS_2 formed at the anode dissolves in the electrolyte, forming sulphostannate, according to the equation (1) $SnS_2 + Na_2S = SnS_3Na_2$. While the sodium ion reacts at the cathode with the surrounding water (2) $Na_2 + H_2O = 2NaOH + H_2$. By keeping the electrode potential below the Haftintensität of the hydrogen ion, the hydrogen is prevented from being set free and decomposes the SnS_3Na_2 into H_2S, Na_2S and tin, the latter being deposited on the cathode. The equation is (3) $2H_2 + Na_2SnS_3 = 2H_2S + Na_2S + Sn$. The hydrogen sulphide, formed according to equation 3, and the NaOH, formed according to (2), will react and regenerate Na_2S, the equation being (4) $H_2S + 2NaOH = Na_2S + 2H_2O$.

flowers of sulphur. The sulphur forms sulphide at the anode, and since it acts as a depolarizer it is possible to start the electrolysis with low voltage. If no flowers of sulphur are added before new anodes are introduced the raw tin anode behaves as an insoluble anode, and as soon as the circuit is closed the voltage rises to about 0.6 volt, with violent evolution of gas and decomposition of the electrolyte, but without deposition of tin. The cathodes get dull and are no longer suitable for tin deposition. But it is possible to use the same electrolyte repeatedly for electrolysis, if every time before introducing new anodes flowers of sulphur or sulphur in other forms are added to the bath. The electrolyte may thus be kept in good condition for several months.

(4) Since the electrodes are arranged in this process according to the multiple system, and since the tension (0.1 to 0.18 volts), and, therefore, the resistance are very small, it is difficult to distribute the electric current uniformly over all electrodes of a bath. The slightest irregularity in the resistance of the contacts greatly influences the distribution of the current, and therefore the uniform working of the electrodes. It is necessary to bring all anodes and all cathodes of a bath to the same electrical potential. This can be accomplished in a very simple manner by using sufficiently large cross-sections for the copper bar and for the electrode contacts, so that their electrical resistance is practically negligible. By directly soldering the electrodes to the homogeneously tinned conductor bars, it is possible to obtain perfectly uniform contacts in a simple and rapid manner, so that the uniform working of the electrodes is assured. It is also advantageous to connect all parallel electrodes of a bath together by soldering with tin strips of sufficient thickness.

(5) It is of importance not to interrupt the current during electrolysis, since otherwise the polarization current generates gas at the anodes and oxidizes the cathodes and fouls the electrolyte.

The first experiments on a large scale were made by the inventor, Mr. Claus, for the firm of A. Strauss & Co. in the year 1902, in Birkenhead (England). Four lead-lined wooden tanks were used, which were connected in series. Each tank was 2.4 meters long, 70 cm. wide and 90 cm. deep. In each of these tanks 30 anodes of 93 per cent Peru tin were arranged according to the multiple system, 70 cm. long, 55 cm. broad and 1 cm. thick, and the same number of tinned-iron-sheet cathodes of about the same size was provided. The electrolyte used was a 10 per cent commercial sodium sulphide solution of 1.070 specific gravity.

The dynamo produced a current of 1,000 amps. at 1 volt, so that every tank consumed about 0.25 volt. The temperature of the electrolyte was kept between 80° and 90° C. The baths were heated indirectly by steam, by means of lead coils placed on the bottom of the tanks.

After a fortnight of continuous electrolysis, the anodes were consumed about one-half, and on the cathodes a very beautiful and compact metallic tin deposit was obtained which was melted and yielded about 1 ton of tin of 99.9 per cent purity.

All foreign metals, all silver and all gold and also some tin remained in the anode slime. The experiment was not continued, but the establishment of a large plant for a yearly production of 1,000 tons pure tin was decided upon.

The plant was erected in Bootle, near Liverpool, in 1905. It consisted of 100 tanks, a Dowson gas producer, a gas engine and a dynamo for 1,500 amps. and 25 volts. The tanks were 3 meters long and otherwise arranged in the same way as in the preliminary experiments.

In starting the operation, it was first tried to use simple iron-sheet cathodes. But it was impossible to obtain on such cathodes a coherent metallic tin deposit, since the tension always rose to 2 volts.

Claus, who superintended the work up to this time, died in August, 1905, without having seen the final success of the endeavor of twenty years of his life. In September of the same year I was placed in charge of the work. After replacing the iron cathodes by pure tin cathodes and by following strictly the other conditions of the Birkenhead experiment, I succeeded without difficulties in getting a solid metallic tin deposit.

But when I tried to use the same solution for a second run the voltage increased suddenly up to 0.6 volt and violent generation of gas at the electrodes took place. The reason was that the commercial sodium sulphide contained originally a small amount of poly-sulphide, which acted as depolarizer during the first run and was therefore consumed, so that it was no longer available for the second run.

ELECTROLYTIC TIN

(Photographic reproduction of a simple piece of tin sent by the author. The piece is bent to show thickness. The cathode plates are, of course, straight and flat.)

By dissolving 1 per cent flowers of sulphur in the electrolyte each time when new anodes were suspended and by strictly following the above conditions (1) to (5), it was possible to use the same solution as often as desired. Twenty-five tanks were then set to work, which produced about 100 tons of pure tin during six months.

Method of Working.

The electrolyte is preferably 10 per cent Na_2S solution, obtained by dissolving the 60 per cent commercial Na_2S in the

necessary quantity of water, settling and, if necessary, filtering. Solutions with higher contents of Na_2S may also be employed. They have the advantage to permit the use of higher current densities and to shorten therefore the duration of the electrolysis.

During electrolysis some of the sodium sulphide is always lost by oxidation of the electrolyte and by formation of sulphostannate. It is therefore necessary to test the solution from time to time and to add some Na_2S. For each 100 kg. of electrolytic tin produced an addition of about 10 to 15 kg. Na_2S (counted as Na_2S) is sufficient. The amount of tin in form of sulphostannate in the solution increases continuously during electrolysis, because more tin dissolves from the anode than is deposited on the cathode. At the cathode there is therefore a very slight generation of hydrogen gas, but this is hardly noticeable. The amount of tin in the electrolyte reaches a maximum of about 2.2 per cent Sn after three months. It does not increase any more after it has reached this amount, but remains constant. If the solution cannot be used any more the tin may be precipitated from it by means of sulphuric acid as tin sulphide, and is then converted into SnO_2 by roasting and finally reduced to metallic tin.

The heating of the electrolyte is best accomplished indirectly by steam. If lead coils are used for heating, the pipes should be of small diameter (exterior diameter not more than 4 cm.), since pipes of larger diameter are easily destroyed by strong rushes of water when the steam is turned on. To save heating expenses, it is advantageous to cover each tank with a wooden cover and to immerse the electrodes below the surface of the electrolyte whereby the evaporation is diminished, and to use the waste steam of the steam engine. The evaporated water is to be replaced by continuous new supply.

The anodes are cast in iron moulds from raw tin containing not less than 90 per cent tin, because the anode slimes remain partly attached to the anodes and increase the voltage too rapidly if the anodes are too impure. This increase of voltage is the quicker the more impure the anodes are, so that tin anodes with about 85 per cent of tin can only be consumed to half the thickness of those of 90 per cent tin. If, therefore, metal with less than 90 per cent tin are to be refined it is better to mix this metal with purer brands in order to bring the mixture up to 90 per cent. Material containing a large amount of iron, say, more than 2 per cent, is not suitable for anodes.

If these anodes are about 75 cm. long, 50 cm. wide and 1 cm. thick, their weight will be about 30 kg., and the workingmen will be able to handle them without difficulty. A greater thickness of the anodes would not be economical, since it would only increase the weight of the residue and the loss of interest on tin. The cathodes are cast as very thin plates from pure tin from the previous operation. The weight of a cathode is about 8 kg.

The ampere-hour efficiency is nearly theoretical, if short circuits between anode and cathodes are avoided. The temperature of the electrolyte should be at least 80° C. The higher the temperature the better the deposit. The cathode deposit is shown in Fig. 1. If I am not mistaken it is the first time that metallic and compact tin deposits of any desired thickness have thus been obtained electrolytically.

The deposit could be still improved by adding a colloid to the electrolyte, for example, gelatine as used in the Betts process for lead refining.

The current density is about ½ amp. per square decimeter anodic or cathodic surface. In order to use a higher current density it is necessary to increase the amount of Na_2S in the electrolyte accordingly as the voltage is increased. The distance between the electrodes is preferably made as small as possible, about 3½ cm.

The tanks are preferably made from iron, since wood gets deformed at a temperature of 90° C. They should not be longer than 2½ meters, since otherwise it becomes difficult to distribute the current uniformly over all electrodes of a bath, the conductor bars would have to be made very thick.

The voltage between the electrodes is about 0.1 to 0.18 volt, and the voltage of the whole bath is about 0.2 to 0.28 volt if a current of about 1,300 amps. is used. As source of power, steam engines are more suitable than gas engines, because steam engines are not liable to cause so many stoppages (see above condition No. 5), and the waste steam may be used for heating the electrolyte.

The management of the process is as follows: Each tank is operated independently of the other baths. First, the anodes and the straightened cathodes are suspended in the bath, the contacts are soldered and the clear and, if necessary, filtered, solution is allowed to flow in. Then the steam is turned on and at the proper temperature the circuit is closed.

At the beginning the electrode voltage is about 0.1 volt. It increases continuously and will be 0.10 volt after a fortnight. The positive and negative leads of the tank are then short circuited, and the electrolyte is allowed to flow out very slowly by means of a syphon, so that the anode slime is not stirred up.

While the tank is slowly being emptied the electrodes are washed at the same time by the vapors rising from the surface of the electrolyte, so that further washing of the electrodes, involving losses of electrolyte, is unnecessary.

When the bath is empty, the electrodes and the anode mud are removed, new electrodes are introduced, the contacts are made, the electrolyte to which the necessary quantity of sodium sulphide and of sulphur has been added is allowed to flow in, the steam is turned on, the short circuit is removed and the electrolysis is started again. The cathodes, which are taken out of the bath may be directly melted, whereby a metal containing 99.9 per cent tin results. The anode slime is removed from the anode residues by scraping with a T-piece and the remaining residues are melted in the furnace.

It is preferable to first roast them in order to remove the sulphur. The anode slime contains in dry state about 12 to 15 per cent Sn, 20 to 30 per cent Sb, 20 to 30 per cent Pb, ¼ per cent Bi, ½ to 1 per cent (150 to 200 oz.) Ag, 1 to 2 per cent Fe, 1 per cent Cu, 0.001 per cent (0.25 oz.) Au. The other parts are sodium, sulphur and oxygen. The different metals may be obtained from the slime by the known methods. In washed and dried condition its weight increases about 10 per cent on heating in air; this proves that most of the metals are in metallic condition. The anode slime on the outside contains less tin (12 per cent) than that in the interior of the residue (27 per cent tin).

With a current of 1,200 amps. we obtained from every bath during a fortnight's electrolysis from 500 kg. 93 per cent Peruvian tin about 370 kg. 99.9 per cent pure tin, 100 kg. anode slime, 16 kg. cathode dross and 80 kg. anode dross, while 9 kg. tin remained in the solution as sulphostannate.

It is to be remarked that the anodes are not completely consumed, but that about 50 per cent of the tin remains in the residue. It is, therefore, necessary to use for the above electrolysis about 1,000 kg. 93 per cent anode tin, from which 500 kg. will remain as residues and will be melted after finished electrolysis. There are also necessary about 300 kg. pure tin for the starting cathodes, so that together 1,300 kg. tin must be suspended in the bath to produce 370 kg. of pure tin.

The cost of the plant for a yearly production of thousand tons pure tin will be about £5,000.

The expenses of the treatment for producing 1 ton (= 1,000 kg.) of pure electrolytic tin with such a plant are in shillings:

100 kg. sodium sulphide (counted as 100 per cent Na_2S)	25
25 kg. flowers of sulphur	3
Wages	32
Heating of the electrolyte	10
Cost of electrical energy	14
Loss of interest on tin stored in the process (5 per cent)	30
Repairs	3
Regeneration of tin from the electrolyte	8
Amortization (10 per cent)	10
	135

There are to be added at least 40 shillings for losses of tin in the electrolyte, treatment of the by-products and treatment of the anode slime, so that the expenses per ton electrolytic tin will be about 175 shillings. On the other side there is a gain from winning the silver and other metals contained in 1 ton of raw tin as follows:

	Shillings.
30 to 40 kg. of lead	14
30 to 40 kg. antimony	70
20 to 30 oz. silver	50
¼ oz. gold	2
½ to 1 kg. bismuth	10
	146

We must keep in mind that the treatment of the anode slime offers great difficulties on account of the great amount of tin it contains, which will involve great losses of metals and make the treatment very expensive, so that the gain will not be 146 but perhaps only 115 shillings.

The electrolytic tin refining process will, therefore, only pay if the raw tin can be obtained at a much lower price than the market price of pure tin. In the year 1905 the price for 1 ton of 90 per cent raw tin was about £112 to £116 on the basis of £130 for pure tin. In 1 ton of 90 per cent raw tin are contained 900 kg. pure tin, £117; the gain from the foreign metals, £5; total, £122; expenses for treatment, £7½; remaining, £114 10 shillings.

It is seen that the profit to be expected is very small. On the other hand, a great risk is run in this process, since the price of tin is very unsteady, and because for a yearly production of 1,000 tons of tin a stock of 150 to 200 tons tin is necessary.

But the greatest, nearly invincible difficulty for this process will be the getting of the raw material, as the whole yearly production of 85 to 93 per cent tin that is put on the market amounts to only about 1,000 tons and smaller plants will work much more uneconomically.

Crefeld, Germany.

The Iron and Steel Institute Meeting.

In continuation of the abstracts, published in our last issue, we herewith give abstracts of those papers which were presented but not read. For an account of the proceedings the reader is referred to the regular monthly letter of our London correspondent.

Carbon-Tungsten Steels.—Mr. Thomas Swindon's paper describes a research having for its object an investigation of the influence of varying percentages of carbon in the presence of a constant percentage (3 per cent) of tungsten carried out in the metallurgical department of Sheffield University. The paper is somewhat lengthy, covering thirty-five pages of printed matter and illustrated by fourteen plates of diagrams and microphotographs. The author's main conclusions are summarized as follows:

1. A definite alloy of iron and tungsten, having the empirical formula Fe_3W is formed on melting the two elements together in sufficient proportion.

2 The 3 per cent of tungsten has decidedly raised the tenacity of the steels without materially lessening the ductility. The elastic ratio is much higher than for carbon steels. A maximum tenacity is seen at 0.9 per cent carbon, but brittle hardness continues beyond this, as shown by alternating stress tests

3. Below a certain initial temperature all the steels examined show critical points as for carbon steels.

In steels below 0.35 per cent carbon, heating beyond this initial temperature lowers Ar 1 to a definite "low point"; Ar 2 is practically unaffected; Ar 3 is gradually suppressed in its normal position, but appears again below Ar 2, forming the upper maximum of the low point.

With carbon contents 0.35 per cent to 0.9 per cent Ar 1 is first lowered, and then increased heating displaces Ar 3.2 towards Ar 1. Beyond 0.9 per cent carbon the Ar 3 2.1 point is lowered as a whole by heating beyond the lowering temperature, and produces a single low point.

As the carbon increases higher initial temperature is needed for the lowering to be effected.

The "low point" is practically constant at 570° for 3 per cent tungsten steels.

Rate of cooling does not affect the position of the low point after lowering has once taken place.

The range of recalescence is not merely widened, but the critical point is at a distinct lower temperature.

At Ac 1, on heating, a change of similar nature to the carbon change occurs; and at the lowering temperature further change in constitution takes place, the reverse of which is at the low point.

No recalescence has been found at the lowering temperature.

4 Microscopic examination confirms the cooling curves, showing the eutectic composition practically unaltered. The structures resemble carbon steels, but are finer in pattern.

Sentinel Pyrometers and Their Application to the Annealing, Hardening and General Heat Treatment of Tool Steel, by H. Brearly and F. Colin Moorwood.—This paper consists of an essay on pyrometry in general, and the use of sentinel pyrometers in particular, composed of metallic salts with easily observed and reliable melting and solification points, such as sodium chloride (770° to 775° C.), potassium chloride (740° C.), barium chloride (930° C.). These are cast into small cylinders and placed in small porcelain saucers upon the floor of the furnace or oven to be controlled. On the temperature limit being reached the cylinders soften and melt down into a clear liquid in the saucer. Mixtures of two salts can be used.

The Distribution of Sulphur in Metal Ingot Moulds, by J. Henderson.—This note discusses the segregation of sulphur, and shows that the very high sulphur is concentrated in the central of the metal at the top and diminishes very considerably towards the sides. It is, therefore, urged that in sampling such a mould at the top, without taking into consideration the proportion of the top to the rest of the mould, the results obtained, as regards sulphur, must be very unreliable, and consequently of no value. The mould in question measured 7 feet long and weighed 4¾ tons. A section 2 inches deep cut from the top would weigh 270 pounds. The average composition of that 2 inches is estimated from the data available to be practically 0.095 per cent sulphur. Taking the remainder of the mould to be 0.043 per cent, the average for the whole is 0.044 per cent sulphur, a percentage with which there is no reason to find fault, as regards the use of the moulds, when scrapped, for melting purposes in the open-hearth process. The author suggests that the bottom alone should be drilled, and if the sample so obtained be satisfactory the mould should be passed. This is a matter of vital importance to ingot-mould makers, who are often asked by their customers to supply moulds with a maximum of 0.050 per cent sulphur. As the segregation of the sulphur in the top of the mould is scarcely under their control it is certainly not just to them to sample the top unless in due proportion to the rest of the mould.

Abstracts of Reports on Research Work Carried Out by Holders of Carnegie Research Scholarships.

(I.) Copper Steels, by Pierre Breuil.—The results of the tensile tests obtained show that copper increases the tenacity but does not diminish the ductility of steel, although the proportion to which it has this effect varies with the treatment which the metal has undergone. Annealing renders these steels more similar to each other, whereas quenching intensifies their differences. Low coefficients of tensile strength are never encountered with these copper steels, which from this point of view equal in value nickel steels containing corresponding proportions of nickel.

Shock tests on notched bars have shown that, generally speaking, copper steels are somewhat more brittle than steels not containing copper. This does not, however, imply that they cannot be used, as their resilience is also exceedingly high.

Shock tests on plain bars lead practically to the same conclusion as the preceding tests, but are more trustworthy. The steel containing 0.16 per cent of carbon and 4 per cent of copper is remarkable by reason of its resistance to shock. Copper steels are not more brittle than steels containing the same percentage of nickel.

Torsion tests were carried out only on the ingot steel. The results agree closely with those of th etensile tests. The elastic limit, the maximum tensile strength, and the angle of torsion on breaking, are in harmony with the corresponding figures obtained in the tensile tests.

The hardness of these steels agrees fairly closely with their tensile strength. It is usually greater to those of nickel steels containing the same percentage of carbon and the same amount of nickel when subjected to the same thermal treatment.

Corrosion tests were carried out both on the ingot metal and on rolled bars. Only those steels which are employed commercially—that is to say, containing not more than 4 per cent of copper—were subjected to these tests. The corrosive bath consisted of sulphuric acid at 66° Baumé and of water in equal volumes. It was found:

1. That the ingot metal corroded much more rapidly than the rolled metal.

2. That the loss in weight by corrosion diminished in proportion as the percentage of copper rose.

3. That there were certain anomalous results obtained.

4. That it is particularly in the case of low-carbon steels that the difference between steels containing copper and those without makes itself felt.

All the steels up to 4 per cent of copper are capable of being forged hot without cracking.

The conclusions arrived at by the author as to the micrography of copper steels agreed with those of Mr. J. E. Stead. When over 4 per cent of copper is present, reddish nodules containing a high percentage of copper separate in the ingots, this phenomenon being more marked in proportion as the steel contains a higher percentage of carbon. The chief characteristic of the copper steels which are commercially usable (that is to say, not exceeding 4 per cent of copper) is the fineness of their structure; they contain a large proportion of granular pearlite (or sorbite) in proportion as the percentage of copper is higher. This sorbite affords homogeneity, tensile strength and hardness to the metal, and makes it approximate in character to a more highly carburized steel. The copper in dissolving in the ferrite still leaves this constituent considerable malleability, and as a result of this dissolution, the carbon being enabled to form a carbide, finally divided, and in greater abundance than usual, exerts a special hardening influence in consequence. The resulting metal is harder than steel containing a higher percentage of carbon and less copper and at the same time is less brittle.

From the point of view of the nature of the constituents these steels offer no particular difference from ordinary steels; but the form, distribution and quantity of these constituents are such that the special properties indicated above single them out for the attention of the metallurgists in the same way as steels containing nickel or other elements which are usually more expensive than copper.

(II.) Cast Iron as Cast and Heat Treated, by W. H. Hatfield.—The author's conclusions are:

1. That there is undoubtedly occasionally a great variation in the strength of cast irons of the same composition as cast. 2. That this variation does not appear to follow any distinct rule with regard to the temperature of the casting operations. 3. That a difference in mechanical tests is generally accompanied by a difference in the microstructure. 4. That the inequalities of the metal can be rectified by judicious heat treatment, *i. e.*, the irregularity need not persist after heat treatment, at any rate, under certain conditions.

Here, it is felt, the subject must be left for future research to explain the present lack of correlation between the results of the published experiments upon the influence of casting temperature upon the strength of cast iron as cast and heat treated.

(III.) The Genesis of the Lapland Iron Ore Deposits, by Otto Stutzer.—This report is purely geological, and its ultimate conclusions are as follows: The phosphoric magnetite deposits of North Sweden are all associated with plutonic rocks of the syenite family; they have been formed in a magmatic manner, and, indeed, either as magmatic separations *in situ*, or as perigrinating magmatic separations (magmatic veins and bedded streams). Pneumatolysis plays no inconsiderable rôle in the formation of these ores.

(IV.) The Non-Metallic Impurities of Steel, by E. F. Law.—The impurities have been considered as consisting of five in number, namely, iron sulphide, manganese sulphide, iron silicate, manganese silicate and iron oxide (or manganese oxide).

Iron sulphide very rarely occurs in commercial steels, and is therefore not considered at length.

Manganese sulphide is always present in steel, and is usually harmless. The only instance in which it has been found to exert injurious influence on the quality of the steel is when it segregates with phosphide of iron in the form of "ghosts."

Silicates of manganese and iron are frequently found in steel, and are highly injurious to the quality of the metal. In large forgings they sometimes occur in considerable masses, but in rolled steel they are distributed throughout the mass. In either case they are responsible for many failures. No indication of their presence is afforded by ordinary commercial means, and they can only be detected under the microscope.

Oxide of iron frequently occurs in Bessemer steel. It occurs in a finely divided state, and there is evidence that it is soluble in steel. Methods for the determination of oxygen in steel are given, together with the results obtained in practice. As a general rule, steels which on pickling evince a tendency to blistering are high in oxygen. The effect of hydrogen on steel containing oxide is discussed, and experiments are given with a view to determining the temperature at which the oxide is reduced. The results of these experiments tend to show that the oxide is reduced at 100° C. Iron oxide differs from other impurities present, in its electrical behavior, and the influence of this difference on the corrosion of iron and steel is discussed. It has been found that the presence of oxide accelerates corrosion, and corrosion of welded iron affords an illustration of this action. Other instances of the effects of the presence of oxide be found in the pitting of boiler plates and tubes.

The paper ends with suggestions as to the advisability of taking into consideration the influence of impurities more especially of silicates and oxides, and the effect of the latter on the corrosion of iron and steel.

The Nomenclature of Iron and Steel.—The Council of the Iron and Steel Institute have circulated for consideration the report of the committee of the International Association for Testing Materials. Some forty-four definitions are submitted, and in conclusion the view is expressed that it would be well to decide on a definite carbon content to serve as a boundary line between ingot iron and ingot steel, between puddled iron and puddled steel, and between any other varieties of wrought iron and weld steel. Two plans have been considered. One is to draw this line at 0.32 per cent carbon or its equivalent in other elements, for the reason that this carbon content appears to correspond to the critical point O in the diagrams of Roberts-Austen and Roozeboom. This has the merit of corresponding to a definite physical boundary. The other plan is to draw the boundary at 0.20 per cent of carbon, because this is a convenient place to separate the important classes "soft steel" and "hali-

hard steel" so that if this point was adopted "ingot iron" would be synonymous with "soft steel," and "ingot steel" would be equivalent of the two classes "half-hard steel" and "hard steel."

The Congress have requested the committee to continue their labors with a view to securing the foreign equivalents of the terms defined

Electrolytic Refining of Bismuth.

By Dr. Arnold Mohn.

Very little has been published concerning the electrolytic refining of bismuth containing precious metals. The following quotation is from Prof W. Borchers' German book "Elektrometallurgie":

"There is no difficulty in parting bismuth containing precious metals in acid aqueous solutions of the more easily soluble salts of bismuth. Although the bismuth is thereby not deposited in a well cohering condition, this is no great disadvantage for the electrolytic refining of bismuth, since the

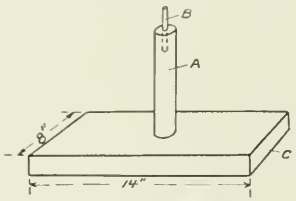


FIG. 1.—CAST ANODE.

smelting of metallic bismuth in powdered form offers comparatively little difficulty. The precious metals remain, of course, at the anodes. In view of the relatively small quantities which will be treated by such a process, stoneware vessels are mostly used as electrolytic cells."

A recent patent by Mr. Anson G. Betts relates to the electrolytic refining of silver containing bismuth with methyl sulphuric acid as electrolyte.

I had an opportunity to become practically acquainted with the electrolytic refining of bismuth, the object being the parting of a Mexican lead-bismuth bullion of the following composition:

	Per Cent.
Pb	81.10
Bi	14.50
Sb	1.58
Fe	1.46
Zn	0.43
As	0.29
Ag, Au, Cu	0.40
Co, Ni	traces

It was intended to recover the lead, bismuth, silver and gold. The process used was a combination of electrolytic and metallurgical processes, namely:

First—Electrolytic refining of lead by the Betts process.

Second—Purification of the slimes.

Third—Electrolytic refining of bismuth.

Fourth—Electrolytic refining of silver and gold.

Anodes cast from the bullion are electrolyzed in a solution of 6 per cent $PbSiF_6$, 14 per cent H_2SiF_6 (total acid). The lead deposited on thin cast cathodes is quite pure. It contains only about 0.01 per cent of Bi. In the anodes which retain their original form there remain Bi, Sb, As, Cu, Ag and Au. I will not give here a description of the Betts process, since it has already been described in detail in this journal, but I will say that in the case of which I speak it was very successful.

The cathodes are melted and cast into ingots; if they contain any Bi, Sb and Sn it is removed by poling.

The anode slime is scraped off and partly directly broken off from the thin middle layer of the anode. This work is easy, but on account of the danger from hydrofluoric acid the workingmen must always wear rubber gloves. An analysis of these slimes give

	Per Cent.
Bi	83.92
Sb	6.80
Pb	4.50
Ag	2.48
Cu	1.70
Insoluble SiO_2 and Au..	0.50

After having been removed from the anodes the slimes are placed on a movable lead-lined filter box, are washed with hot water, and after having been dried they are mixed with caustic soda and soda ash and then treated in a reverberatory furnace until all As, Pb, Sb are removed. For removing copper an addition of sodium sulphide is used.

Samples are taken, and if a sample gives large leaves and yields a clear solution in concentrated nitric acid, the firing is stopped and the casting of the bismuth anodes begins. These anodes consist of rectangular plates, the thickness being 1¼ inches, the width 8 inches and the length 14 inches, with a round rod or candle in the center for connection to the electric circuit.

These round rods or candles are separately cast. Two halves of a 2½-inch iron tube, held together by means of clamps, are mounted on a wooden block and serve as mould.

On account of the brittleness of the alloy a copper pin is cast into the head of the candle to make the connection with the cable. When the anode plate is cast the candle is simply placed in the center of the mould. Fig. 1 shows a cast anode. A is the candle, B the copper pin and C the anode plate proper.

The electrolyzing apparatus is arranged in the same way as described in Balbach's United States patent 588,524 for parting silver and gold. Twelve stoneware tanks are used as electrolyzing vessels. They are placed lengthwise in two rows and rest on brick.

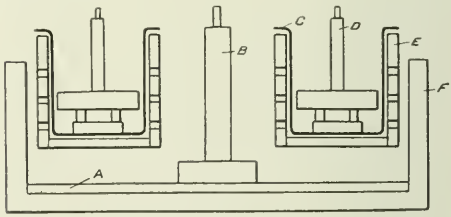


FIG. 2.—VERTICAL CROSS-SECTION OF ELECTROLYTIC CELL.

The anode boxes with lattice bottoms and perforated longitudinal walls are suspended in pairs across any electrolyzing cell. These filtering boxes are lined with a filtering cloth on which a small wooden frame is placed. The anodes rest on this frame. The small wooden frame is necessary so that the electrolyte can circulate directly below the anodes.

Acheson graphite plates are used as cathodes. They are placed directly on the bottom of the cells. It is unnecessary to provide a special joint between the plates, since in time bismuth accumulates firmly in the crevices and thus forms the joints. For the connection to the outside electric circuit a heavy bismuth candle is used which rests on the graphite plates.

Fig. 2 shows a vertical section of the electrolytic cell and Fig .3 a plan. In Fig. 2 A is the graphite cathode, B the bismuth candle resting on the graphite, D the anode, E the filter box and C the filter cloth. F is the electrolytic tank.

In order to prevent consumption of the anode candles their ends are covered with paraffine, so that they may be used

several times, a new anode plate being simply cast onto them

The analysis of anodes gave the following results:

	Per Cent.
Bi	94.0
Pb	2.20
Ag	3.13
Cu	0.48
Sb	0.11
Au	0.07

The electrolyte used is a solution of bismuth chloride and free hydrochloric acid. It is made by dissolving pure bismuth in nitric acid, precipitating the bismuth as oxy-chloride, washing the precipitate and finally dissolving it in HCl and diluting it to a concentration of 7 per cent Bi and 9 or 10 per cent HCl.

The electrolysis is carried out with a cathodic current density of 20 amps. per square foot, while the current density at the anodes is three times this amount. The voltage at the terminal of the cell is 1.2.

Of course, with this high-current density, all possible impurities pass into solution together with the bismuth. From the electrolytic potential series it is seen that the metals, as far as they do not form insoluble chlorides, pass into solution in the following order: Pb, Bi, Sb, Cu, Ag and Au.

Lead dissolves first. Its concentration in the electrolyte is about 0.1 per cent and crystals of lead chloride are floating on the surface of the bath. Part of the lead goes into the bismuth deposit, so does Sb. The concentration of Cu in the

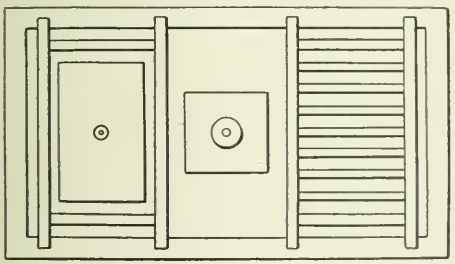


FIG. 3.—PLAN OF ELECTROLYTIC CELL.

electrolyte may be up to 0.2 per cent without depositing this metal to any extent together with bismuth.

The greatest difficulty in the electrolysis comes from the silver. It is intended that it should remain unattacked, or as silver chloride together with the gold in the anode filter boxes. But as a matter of fact after a few weeks silver is found in the bismuth deposit, and the silver content amounts up to 0.3 per cent.

By using good filters, two linen cloths with an intermediate layer of filter paper, it was shown that this high content of silver in the bismuth cannot be solely due to mechanical transfer of the silver to the cathode.

The real reason is the solubility of AgCl in $BiCl_3$. When the silver is in solution it is deposited before the bismuth, as is clear from he potential series.

To keep the silver away from bismuth, there is only one possibility, namely, the diminution of the anodic current density.

The bismuth is deposited on the graphite cathodes, and especially below the anode filter boxes in crystalline form, in form of trees or in beautiful mushroom form, and after the filter box has been taken out the bismuth deposit is removed by means of a wooden ladle. There is often formed on the cathodes a firm metallic deposit which is broken off by means of a chisel.

For a given current density it is important to maintain the concentration of the electrolyte constant, according to the results of the analysis. This is accomplished by adding either $BiCl_3$ or HCl.

If the concentration in bismuth decreases too much the bismuth is no longer deposited in gray crystalline form, but as a black voluminous mass. It then fills the intermediate space between the anode filter boxes and the graphite cathodes, and thus causes trouble.

If there is not sufficient free acid present, bismuth oxychloride is formed at the anodes and the voltage rises rapidly.

The bismuth obtained is washed in filter boxes with hot water and then melted at a moderate temperature in plumbago crucibles and the slag is skimmed off.

If the metal has not the proper appearance and the right color it is melted with nitrate and caustic soda until all traces of Pb, As and Sb are removed. A metal of about 99.8 per cent purity is thus obtained. The chief impurity is silver.

The slime which remains in the anode filter boxes and which consists of Ag and Au, besides Sb and Bi, is boiled with dilute HCl until all bismuth oxy-chloride is in solution; it is then filtered, washed and dried, and is then melted with sodium carbonate and cast into anodes for the separation of silver and gold.

For the silver cells the same arrangement of Balbach with anode filter boxes and graphite cathodes is used and the parting of the metals takes place, as is generally known, in $AgNO_3$ and HNO_3 as electrolyte.

From the wash-water, due to the washing of bismuth and of the bismuth slimes, bismuth is precipitated with sodium carbonate, dissolved in HCl and precipitated as oxy-chloride, washed, dissolved again as chloride and added to the bismuth baths according to requirements.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

THE IRON AND STEEL INSTITUTE.

SECOND DAY'S MEETING.

Discussion on Steel from High Silicon Phosphoric Iron.—Two papers by Mr. A. Windsor Richards were down for joint discussion, but the author's appeal to the chair for separate discussion on account of their different characters was acceded. After a brief resumé of the first paper on the "Manufacture of Steel from High Silicon Phosphoric Iron" (abstracted on page 262 of our last issue), Prof. Turner opened the discussion by remarking on the wide interest of the paper, which revealed the fact that apparently manganese was no longer an essential constituent. The use of oxide of iron was the chief feature of the process. He believed that tentative experiments had previously been made along similar lines in South Staffordshire with some measure of success, but nothing definite had been done.

Mr. Arthur Cooper, speaking of experiments made at the North Eastern Steel Works along the same lines which had not been so successful, said, in Mr Windsor Richards' works they used larger converters and also better ore. What with delays and so forth, the net result was that whilst they produced a fairly good steel it was not so good as steel made from ordinary basic iron containing manganese, and was appreciably dearer in cost. As to phosphorus, it was just as easy to make good steel from pig containing 2% as 1% per cent phosphorus, so long as the pig was uniform.

Mr. Vaughan Hughes asked for analyses and tests of the steel produced by this process.

Mr P. C Gilchrist stated that the paper was not only exceedingly interesting but was theoretically correct. He thought that basic steel of the future would be made in the open-hearth furnace and not in the Bessemer converter, and that Mr Richards' process would have its most successful applications in the open hearth.

Mr Saniter expressed his pleasure at the author's concurrence with views which he had long held that manganese was unnecessary in steel marking. This point was replied to by

Mr. Riley's remark that manganese was not necessary with pure iron or steel, but merely a physic for impure irons. Mr. Paul said that the paper before them dealt with a hard rail steel. Did the same conclusions apply to structural steel? Mr. Twynam asked for complete analyses of the slag, and asked whether the lime came from the sides of the converter.

Mr. A. Windsor Richards, in reply, said that their experience certainly differed from Mr. Cooper's. It was expensive to put manganese and phosphorus into iron, and more expensive to get them out. He promised to give Mr. Hughes the information asked for, and disagreed with Mr. Gilchrist's view as to the open-hearth furnace, and stated that he considered that the Bessemer process had now a long lease of life.

Discussion on Steel from Pig Iron Containing Chromium, Nickel and Cobalt.—Mr. Richards' second paper (abstracted on page 262 of our last issue) was briefly introduced. Mr. Saniter opened the discussion and characterized the subject as both novel and interesting. Further, the ore used would be really valuable if the process could be worked economically. The removal of the second and third lots of slag would be more difficult than the sulphur; perhaps a tilting furnace would be the outcome. As to the author's test figures further particulars would be of value giving the elastic limit and tensile strength.

Mr. Vaughan Hughes said that, in experimenting with armor piercing shells, he had produced a similar steel with more carbon.

Mr. Henderson enquired whether a pig iron with 0.5 per cent of chromium would permit of fairly easy working in an open type of furnace. Unless this were possible the ore in question would be used only as a specialty.

Mr. Gilchrist asked for a sketch of the furnace, and remarked that the new steel was very beautiful and would have wide uses.

Mr. Cooper, in a reminiscent vein, told how thirty years before, in Sheffield, they had received a pig iron from Tasmania with 6.2 per cent of chromium. They made up a charge with one-fourth of this, and rolled into rails and obtained results which so astonished them that they reserved this stock of pig to help them out on special occasions.

Mr. Riley mentioned that 2,000 tons of the said pig iron, which was a white iron with 0.2 per cent of sulphur, came to this country. He had tried to puddle it and entirely failed, and Mr. Cooper had purchased the entire quantity at a very low price.

Mr. Stromeyer narrated a case of brittleness in chrome steel which bent perfectly well immediately after rolling, but was quite brittle in twelve weeks, and suggested that while chromium might initially improve steel it might cause depreciation later on.

Mr. Lester asked for complete analyses of the final slag, and anticipated the time when ores containing chromium such as existed in large quantities in India would have to be worked.

Mr. Duffield said that he had attended to the making of 8,000,000 tons of Bessemer steel, and had used chrome iron to help him out of difficulties, and had had some of his best steel when he had added pig containing from 3 to 4 per cent of chromium.

In reply, Mr. Richards spoke chiefly upon the question of slag removal, the chief point regarding which was to remove the slag before it got too thick. As regards the order of the elimination of the metalloids it was very simple. The chromium oxidized rapidly with the silicon, and after the silicon was removed only the carbon had to be got rid of.

Steam in Gas Producer Practice.—The interim paper by Dr. W. A. Bone and R. V. Wheeler (abstracted on page 263 of our last issue) provoked a long but not very interesting discussion. The speeches were over-long, and Sir Hugh Bell had to hint twice to one speaker that he should be brief. After the second rebuke from the presidential chair, the audience closured the speaker, discouraging further remarks by mild but continued stamping. If more audiences would so closure verbose orations it would add to the respect in which scientific meetings are held. In the discussion, Mr. Armatage spoke about high temperatures as giving best ammonia recovery, high thermal efficiency and freedom from clinkering. Mr. Sahlen remarked that producers were too frequently left to take care of themselves, whereas they required intelligent management. Mr. Thwaite urged the superiority of carbon monoxide in comparison with hydrogen, and pointed out that the proportion of carbon monoxide increased with the height of the incandescent fuel in the producer. He further expressed the view that steamless air-blown generators were more efficient than steam ones. Mr. Lynn, in a very lengthy speech, transgressed the ten minutes' rule, lost the attention and sympathy of the meeting, and incurred the rebuke of the chair. The speaker's chief point was that the author's figures of efficiency would not apply to a Mond plant working under normal conditions. Mr. Stobie favored gas producers into which steam was not injected, as in making steel bars for Sheffield crucible steel makers, no oxidation took place with open-grate producers; injected steam led to a great oxidation of the metal, and after all water was not a fuel. Mr. Walton Dixon said that the ultimate practical effect of the paper became, whether steel makers should go in for ammonia recovery or not. The authors presented the alternative that if gas was wanted ammonia need not be reckoned upon; if plenty of ammonia was wanted, people need not trouble about the gas. Commercially and theoretically they might be correct—from the practical standpoint they were not correct. Actually if gas was needed for reheating furnaces the ammonia must be reduced. Prof. Bauerman asked for the ratio of air to water in the blast used. As regards the Mond producer it should be worked in its entirety.

In reply, Prof. Bone hit back trenchantly at his critics, as he and his co-author had directly disclaimed any attempt to deal with the efficiency of the Mond process, and that his critics had gone beyond the limits of the paper.

The Effect of Manufacture on the Properties of Steel.—Unless the meeting was completely prostrated by the long and not wholly relevant discussion of the preceding paper it is almost impossible to account for the absurdly brief consideration given to Mr. F. W. Harbord's valuable paper (abstracted on page 263 of our last issue). This was as compact and impartial a review of the subject as could possibly be conceived. It may have been that its comprehensive survey was so just that the friends of different methods of manufacture were left without any case whatever to present. There were only two contributions to the discussion: the first by Mr. P. C. Gilchrist, who asked Mr. Harbord for an additional column giving the amount of oxide of iron present, as he was convinced that the difference in hardness between the four classes of steel was due to this factor. Then Prof. Turner regretted that the author had merely contented himself with recording facts, and had advanced no theories to account for the differences in hardness. In reply, Mr. Harbord promised to endeavor to carry out Mr. Gilchrist's suggestion, for which he thanked him. As regards Prof. Turner's enquiry, he had thought it was wiser to define the facts rather than advance explanations.

Ageing of Mild Steel.—The meeting's reception of Mr. C. E. Stromeyer's paper (abstracted on page 264 of our last issue) was, on the whole, suggestive of toleration extended to a brother weak in the faith, rather than the denunciation of a creator of bogies which might have been expected. Perhaps, because the author had too large an assortment of horrible examples of fractured steel plates to throw (metaphorically, of course,) at their heads.

Mr. Saniter suggested that one source of boiler failures lay in the sudden cooling to which some boilers were subjected at the time of cleaning—brittleness due to shortening following. While he agreed with the author that some steels did show a deterioration on ageing, other steels showed a distinct im-

provement. Those steels most subject to ageing contained oxide of iron.

Mr. Ainsworth commented on the fewness of boiler explosions and accidents to structural material, and urged that Mr. Stromeyer's cases must be regarded as quite exceptional.

Mr. W. Rosenhain urged that Mr. Stromeyer's cases were due to severe local strains, and proposed a long systematic series of tests as to the ageing of steels of normal and severely strained composition.

Mr. Duffield talked about the dangers of piping in soft ingots, and depreciated the use of too soft steels. They wanted more carbon and metal free from oxygen.

Mr. David Colville expressed his view that ageing did not take place. Strains might have been occasioned by the rolls being slightly out of truth, such strains being locked up in the plate. Mr. Stromeyer ought to look for these and not for ageing. The temperature and time occupied in annealing were important.

Mr. Hall referred to the condition of the charcoal iron used in the dismantled Niagara Bridge. After thirty or forty years it was found that the strength of the plates was within 5 per cent of the initial value.

In reply, Mr. Stromeyer admitted the possibility of local strains, and deprecated repeated hydraulic tests year by year. A calking effect was the same as nicking and set up strains. He did not think Mr. Rosenhain's series of experiments necessary. Discussing the relation of ageing and fatigue, Mr. Stromeyer expressed the view that these actions were converse, and that material which would fatigue easily would not age easily, while materials which aged rapidly would not fatigue easily.

Sir Hugh Bell's vote of thanks to Mr. Stromeyer, the reading without discussion of a thermo-dynamically weak paper by Mr. A. J. Capron on "Induced Draught for Steam Raising," and a graceful reference from the chair to the undiscussed papers, ended the most business-like session which the Institution has held for many a long day.

Exhibits at the Royal Society's Conversazione.

Apart from gyroscopes—for tight-rope trains on the Brennan system or on the Schlick system to reduce the rolling of vessels—there was very little that was epoch-making in the exhibition on May 8. Three features, however, call for mention.

The Cambridge Scientific Instrument Co. exhibited Prof. Féry's self-contained radiation pyrometer. This pyrometer utilizes the heating effect of the "total radiation" from a hot body, focused as an image of that body by means of a concave mirror. It differs from the already known Féry radiation pyrometer in being entirely self-contained, the image falling on a minute bi-metallic flat spring (Breguet spiral). This becomes partially uncoiled as its temperature rises, and a light pointer attached moves over a dial divided to give direct temperature readings.

The same company also exhibited the universal portable electrometer, designed by C. T. R. Wilson, F. R. S. This is a gold-leaf instrument, with very small capacity and fused quartz insulation. It is suitable for work on atmospheric electricity, radio-activity, etc., and is self-contained, with a means for standardizing the readings, which are very steady even in a fairly high wind.

Dr. F. D. Chattaway, F. R. S., had an interesting exhibit of copper mirrors, produced by depositing copper on glass from an aqueous solution. In the mirrors exhibited the copper had been deposited upon the glass by reducing cupric oxide by an aqueous solution of phenyl hydrazine in presence of potassium hydroxide, which accelerates the action to a remarkable extent. The mirrors are equal in brilliancy to silver mirrors, and on account of the color of the copper are much more beautiful.

The Faraday Society.

My notes on the discussion at the Faraday Society's meeting, held on June 25, must be held over until next month. The evening was devoted to a general discussion on "Hydrates in Solution." As texts or expositions of rival theories four papers were presented, the authors being Messrs. Bousfield & Lowry, Mr. J. C. Philip, Dr. Findley and Dr. G. Senter. A large audience was present.

The Engineering Conference.

The Fourth Conference convened in London in June by the Institution of Civil Engineers covered a most varied field of subjects. It was, of course, entirely sectionalized, but while there was a distinctly metallurgical section devoted to mining and metallurgy, metallurgical papers were also to be found among such sections as "railways," "ship building" and "applications of electricity."

Postponing all mention until next month of metallurgical papers read in other than the railway section, mention must first be made of Mr. C. P. Sandberg's paper on "The Chemical Composition of Steel Rails and Latest Developments." The author, after declaring that a universal specification to suit all cases could not be arrived at, discussed the effect of different elements. He thought engineers had suffered enough from fractures due to a high percentage of phosphorus, especially in cold climates, to make it necessary to limit it as far as possible, in spite of the good wearing results of high-phosphorus rails.

Sulphur probably presented more trouble to the manufacturer than to the user, because if a high percentage is present the rails will be red-short. No more manganese should be allowed than is absolutely necessary for clean rolling, as he had found many cases of rail fractures attributable chiefly to high manganese.

He had for many years experimented with silicon in rails with a view to obtaining soundness and solidity without brittleness, and had found that for rail steel the effect of silicon added is very different from the effect of silicon left in from the pig iron. When silicon is left in the percentage varies considerably, depending on the heat of the charge, thus causing great irregularity, and as the iron has not been completely converted into steel the metal is of a brittle character. But when the silicon from the pig iron had been eliminated as far as possible and a known quantity of silicon added, in the form of high-percentage silico-spiegel or ferro silicon, he obtained regularity in the percentage of silicon, and, moreover, the silicon then toughened the steel instead of making it brittle, this being largely due to the more complete removal of gases and oxide from the steel.

In general it is desired to obtain a rail as hard as is compatible with safety, and carbon is the most suitable hardener. The author did not specify carbon limits, merely stating that it shall be as high as the safety or drop test will allow. Although not absolutely a criterion the drop test is still the best safety test we have.

Considerable trouble had been experienced on electrified railways, owing to the excessive side wear of the rails on curves. Apart from the question of better wearing steel for their rails in general, one of these railways has introduced the novelty of using a considerably harder steel for check rails. This had shown surprisingly good results, about which he hoped more would be heard during the discussion.

The general purport of the discussion was the consideration of the value of silicon as an ingredient in rail steel. Mr. Ross, of the Great Northern Railway, commenced with a statement of his experiences. He said that it was by no means easy to lay down any fixed rule for the composition of rails. The inter relation of the constituents were complicated and uncertain. He had some Sandberg rails down for twelve months, and found them very good. They contained .441 per cent silicon, .264 sulphur and very little phosphorus. They had tried a few rails with 3 per cent nickel in them; they were most excellent but far too dear for general use. He had great hopes for the silicon rail.

Mr. Willcocks, of the Metropolitan, maintained that the rails

made twenty-five years ago were much better than the present rail. He considered, at considerable length, the abnormal wear which took place with electric traction. Rails with steam traction lasted in a tunnel five years; outside twelve years. With electricity the time became two years inside and five years outside. He then gave a number of figures, all going to show that the Sandberg rail was much more durable than any other. The wear on the Metropolitan was peculiar in that it was largely side wear. The question was to what this side wear was due. He held that the system of traction was to blame. The tram was partly pushed, partly propelled, and the pushing tended to set the bogie against the sides of the rails. Old rails were used as check rails on curves. They lasted about 104 days, losing as much as 7.7 pounds per yard per month. Sandberg hard rails lasted for four months without much visible signs of wear.

The most interesting contribution to the discussion was made by Mr. Short, in charge of the London & South-Western Railway laboratories, who gave particulars of an investigation of 100 broken rails fractured within the last two years. He found that phosphorus up to 0.14 per cent had little or no effect, rails with that amount having lasted twenty-four years. Not one fracture could be traced to that element, which, by giving hardness, prolonged the life of a rail. Sulphur up to 0.145 per cent, silicon up to .2 per cent, and manganese up to 1.5 per cent had no effect. As to carbon, they found percentages of .3 and .52. The latter rail lasted three times as long as the former. With .45 per cent the fracture took place through the fish-plate bolt holes; with .4 per cent they broke clean. The fractures were invariably near the end of the rails. Of the 100 fractures thirty were obviously due to slag rolled in, 60 per cent occurred through solid metal. Of 200 tons of rails used for experiment the wear was found to average 1 pound per yard per year. He held that the modern rail lasts twice as long as the old one.

Mr. J. E. Stead said that the great merit of silicon was that it promoted soundness. Piping could be diminished by teeming very slowly. Much of the differences in results depended upon whether the rails were rolled in summer or winter. The rapid cooling of the rail made it brittle, particularly if there was much manganese present. Phosphorus had a tendency to segregate in patches, and the rail to break through a patch; silicon reduced segregation.

Omitting any references to a paper on reinforced concrete I must mention a brief paper by Mr. Bertram Blount on "The Best Means of Preserving Iron and Steel Work in Railway Construction," which expressed the opinion that the best preservative for iron and steel work exposed to the weather is some bituminous preparation. Natural bitumen is very permanent, but rather costly; coal tar, properly boiled so that the coating shall be neither brittle nor sticky, is almost as durable and is cheap enough. Where the work is exposed to boiler gases, *e. g.*, overhead bridges and station roofs, complete coating with a good layer of hot bitumen has so much practical advantage over paint that no question of appearance should be permitted consideration. For railway structural steel work, such as the frames of buildings or frame foundations, there was, he considered, no preservative so good as lime or cement concrete. This applied whether the steel framing was bedded in concrete or whether it formed an integral part of the concrete, as in the various "ferro-concrete" systems. It was essential that the concrete should be dense and rich in cement, and that the cement or lime should be unexceptionable. Steel protected in this way need not first be cleaned from scale and rust.

The resultant discussion was in the main favorable to Mr. Blount's view, one speaker alone stating in dissent that tar had done much mischief owing to its acid contents.

Mr. R. A. Mallock's paper on "The Action Between Rail and Wheel" was purely physical in its contents, and, assuming an absolutely rigid rail bed, the author tentatively put forward some hypothetical formulæ, which critics in the audience did not accept.

Market Prices During June.

In the chemical trade the price of copper sulphate has receded during the month from £33.10 per ton to £32.10, and ammonia sulphate risen 2s. 6d. to £12.10 per ton. Montreal potash is unchanged. Bleaching powder is quoted at £4.12.6 per ton, and white caustic soda, 77 per cent. at £10.12.6 per ton. Zinc sulphate is quoted at £8.

In the metal market, copper has been in a very unstable condition. Opening at £101 per ton the price of £95 was touched on the 13th, rallying to £101; on the 18th and 19th prices broke again, falling to £94 on June 24, and finally closed at £98 on June 29th. Tin prices have also been unsettled, declining to £185 on June 10 and rallying to £191 on June 18, receding to £188 on June 21, and returning to £191 on June 25, and closed at £192.10. Lead opened at £20.17.6 per ton, and commencing to rise on June 7 reached £22.10 on June 17, and commenced to fall three days later. The final price was £21.10.

The chief feature of the month has been a weakening of the iron market, Cleveland pig iron breaking from its high price of 61s. 10d. and falling by the 14th to 55s. 10d., remaining in this neighborhood for about ten days, and closing at 56s. 3d. Hematite prices also broke away from their opening value of 79s. 10d. per ton to 75s. 6d. by the 13th, touching 76s. 10d. on the 19th, with subsequent irregularities, and then rising to 81s. 9d. Antimony has closed at £50 to £55 per ton, thus relieving a strained situation, during which prices once touched £115. Platinum is quoted at £5 per ounce.

London, July 6, 1907.

SYNOPSIS OF PERIODICAL LITERATURE

A Summary of Articles Appearing in American and Foreign Periodicals.

Electric Smelting of Iron Ore in California.

Heroult Process.—We have already referred repeatedly to the work now going on in Shasta County, California, with a view to electrically smelting iron from the large magnetite deposits there available. The *Mining and Scientific Press* of July 20 contains considerable information on the progress of the work both in an editorial and in an article by R. L. Phelps. The deposit of iron ore consists of a large body of magnetite, uniform in texture and analysis, containing from 68 to 70 per cent iron, that is, only 2½ to 4 per cent of impurity. (An analysis gave 70.2 per cent Fe, 2.4 SiO_2, 0.012 S, 0.01 P and 2.4 insoluble.) Although as yet only partially explored, there is evidence to warrant the expectation of a plentiful supply of ore and it is situated as to be conveniently transported to the smelter. The magnetite appears to be associated with diorite and it lies at the contact with a limestone so pure as to serve as a flux in smelting. The iron mine and the limestone quarry are alongside. It is expected that the ore can be delivered for $1.50 per ton to the smelter. Electric energy is obtained from the Northern California Power Co. at $12.00 per horsepower-year in the form of three-phase currents. There was some fear that trouble might be experienced with the three-phase electric furnace by short-circuits between the three electrodes so that the current would not pass through the neutral pole at the bottom of the furnace, which is made of a carbon paste tamped tight and of the same material as the electrodes themselves. However, such fears proved groundless. The experiment is made under favorable commercial conditions, since the best pig iron sells in San Francisco at from $30.00 to $32.00 per ton. It comes by sea from Europe, mainly as ballast, and pays a heavy duty. No iron

is made in California, mainly because a suitable cheap fuel is lacking. For smelting in the electric furnace, charcoal is used as reducing agent, and unlimited timber is available for this purpose at the smelter. It is estimated that the magnetite in Shasta County can be converted into pig iron and placed in San Francisco for $15.00 to $18.00 per ton. This experiment is being undertaken by Mr. H. H. Noble, president of the Northern California Power Co. It is made at his own personal expense. The engineer in charge is Dr. Paul Héroult, assisted by R. Turnbull, N. Petinot and E. Humbert. Three-phase currents, at 30,000 amps., 50 volts, 60 cycles are delivered to the electrodes from transformers supplied with the 22,000-volt current of the transmission line.

The smelter itself is elliptical in form. The bottom of the furnace is formed of heavy cast-iron plates with a covering of tamped carbon to form the neutral point. A tap and trough are provided on one side to draw the molten pig iron onto the molding beds. Owing to the small amount of slag produced it is not necessary to provide a tap for removal of the slag. The ends of the electrodes are kept in the slag rather than in the molten metal. The carbon electrodes are held in copper holders which are water-jacketed. A diagram of the furnace is shown in Fig. 1, where A is the chamber leading

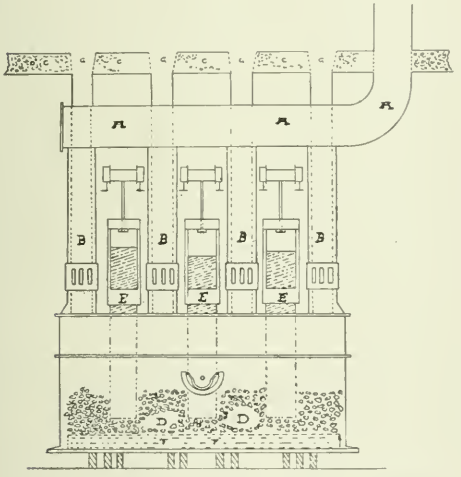


FIG. 1.—HEROULT THREE-PHASE FURNACE FOR SMELTING IRON ORE.

gases from the furnace to the stack; B are combination charge and draught tubes; D is the charge in the furnace and E are the electrode holders. The charge is made of charcoal, limestone and ore. The charcoal is burned in kilns close to the plant.

Water for cooling the water-jacketed transformers and electrode holders is furnished by an 8 hp. centrifugal pump. The current was turned on for the first time on June 29 to dry the lining and test the electrodes. On the evening of July 3 the current was again turned on and the furnace warmed up for the formal start on the morrow. "About 10 o'clock on July 4, the furnace being sufficiently heated, a charge was added and the real experiment began. The daughter of Mr. H. H. Noble had the honor of feeding the first shovel-full of ore. With a low steady hum of the current the smelter ran successfully for 3½ hours, reducing the charge until molten iron collected in the bottom. This proved that the furnace could be operated by a three-phase 60-cycle alternating current. At the end of 3½ hours difficulty was found with the centrifugal pump." Another trouble was later experienced on account of clogging of a charging tube and just as this was being corrected the transmission line was broken by an accident and the supply of energy stopped. However, the repairs have been made and the editorial concludes with the following statements: "As we go to press we learn by telephone from the smelter (280 miles from San Francisco) that five tons of iron have been tapped, that the quality of it is excellent, and that successful results are confidently anticipated."

Electric Discharges Through Gases.

Ozone.—A Franklin Institute paper by J. H. Bridge, published in the May issue of the *Journal* of the *Franklin Institute* deals with ozone, its nature, production and uses. (An ozonizer of the author has been in use side by side with the Vosmaer ozonizer at the experimental plant of the United Water Improvement Co. of Philadelphia.) The author reviews the different forms of electric discharges through air and points out that the one discharge which produces ozone is the silent discharge which is characterized by a dark blue violet color, being a convective discharge, unidirectional from positive to negative. The theory has recently been advanced, and is now gaining pretty general acceptance, that the formation of ozone by the brush or silent discharge, is caused, not by any direct electrical action on the oxygen itself, but is simply a photo-chemical effect, due to the ultra-violet rays accompanying such discharges. This theory originated with the discovery of Lenard, who noticed that if the light from a spark gap was allowed to pass through quartz plate, which is transparent to ultra-violet rays, and to impinge on oxygen, ozone was generated. If, however, a substance impervious to ultra-violet light was interposed, no such action took place. In most forms of ozonizers high-tension discharges are employed, a dielectrics—like glass, mica, or vulcanite being placed across the path of the current to prevent the formation of sparks and arcs. The trouble is, however, that these dielectrics often break. (Although it is not mentioned in the paper it may be stated here that the Vosmaer system does not employ any dielectrics but prevents the formation of arcs and sparks by purely electrical means. The recent failure of the United Water Improvement Co. in Philadelphia is believed to be due to the fact that while the troubles of a dielectric are avoided in the Vosmaer system, yet new troubles were introduced by the special condensers which are required in the system and which are reported to have not proven so fully reliable as is required for commercial work. In the Bridge system, which was also used at the Philadelphia plant, a dielectrics is used but not of glass but of a stronger and a more resistant material so that it is not as liable to break.)

As regards the various yields of existing types of ozonizers, the differences in methods of testing render comparisons unreliable; and, until a uniform method is applied to determine the ozone—content of a given body of gas, no exact comparison can be made between the efficiency of the different types of apparatus now in use. The Siemens & Halske ozonizer, with dielectrics, is reported to yield 20 to 30 grams per kw. hour. Elworthy claims 60 to 70 grams from a machine of similar construction; but no data are available as to the richness in ozone of this product. Otto has published figures showing yields of 20 to 118 grams per kw. hour, the former where the concentration was .852 grams per cubic meter of air, and the latter where it was only .542. Vosmaer with a concentration of 1.5 obtained a yield of 12 to 16 grams. The de Fries apparatus produces about 20 grams with a concentration of 1.0. "Generally speaking, 20 grams per kw-hour has hitherto been considered a fair output if the air treated contains one gram and upwards of ozone per cubic meter." Bridge states that he has improved the efficiency by making use of the fact that the silent discharges are always in the form of hollow cones of light or of cone shape funnels. In all ozonizers hitherto devised, the air is directed against, or around, these cones of light in a plane at right angles to them. Now it is a well known fact that when electricity is discharged from a

point, the surrounding particles of air are electrified, and, being of the same electrical sign, repulsion takes place. The currents of air repelled from the points of a discharging electric machine may be felt by the hand, or seen in the deflected flame of a candle held close to them. With these facts in mind, it is obvious that air, when passed into the influence of a discharge at right angles to its path, is immediately thrust away from it, and any effect which the discharge may have

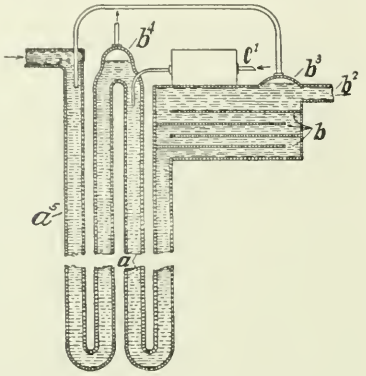


FIG. 2.—WATER STERILIZATION BY OZONE.

on it is but momentary. To overcome these disadvantages Bridge has devised a perforated electrode, and has so "arranged the air supply that it passes through the perforations in fine streams directly into the hollow cores of the discharges taking place on its surface. In this way the air is forced to travel upwards with the discharge, while completely surrounded by it, and then forced through the luminous walls of the discharge. This brings every particle of the air into intimate contact with the discharge. The first tests of the apparatus gave 80 grams of ozone of a high concentration."

The second part of the paper deals with the applications of ozone. Ozone is useful in various chemical manufactures and it is stated with respect to the manufacture of vanillin that in a single month in 1903, the Société Française de l'Industrie Chimique produced 22,000 kilograms of vanillin by means of ozone, which at 35 to 45 francs has taken the place of a product that in 1895 was worth 800 francs. (The same process is also used at Niagara Falls.) Ozone is also useful for bleaching and purifying purposes as well as in thereaputics. The chief application is, however, in the sterilization of water. (A great many sterilizing apparatus have been described and illustrated in former volumes of this journal.) Fig. 2 shows the Howard-Bridge system in which the suction action of the water under treatment draws into itself the ozonized air required for its purification. The excess of ozone which remains unabsorbed and which in some systems is run to waste is here utilized in the preliminary treatment of the water. Raw water enters the pipe a^5 drawing, by suction, unabsorbed ozone from b^3. The waste gases escape at b^4. The current of water in a sucks fresh ozone into itself from the ozonizer c; and after passing around the baffle plate in b, the prified wates escapes at b^2.

Precious Metals.

Advance of Cyanidation.—In our Vol. IV., page 345, we had an interesting article by J. W. Richards on the metallurgical revolution in Guanajuato, Mexico, due to the introduction of the cyanide process. The *Mining and Scientific Press* of June 1 states that Guanajuato and Pachuca are seeing rapid advances in cyanidation and the passing of the patio process. At Pachuca excellent results have been obtained by A. Grothe in his new plant, consisting of five conical-bottom vats, 40 feet high and 15 feet diameter, in which sand and slime are agitated by air. Six horsepower suffices to agitate 100 tons of ore. The extraction is rapid. The cyanide plant of the Hacienda San Francisco has been in operation six weeks, and so successfully that plans are being drawn for changing several pan-mills to cyanide plants. The owners of the San Rafael mine are about to add twenty stamps to the forty already at work, using three tube mills for regrinding. The pulp will be crushed in solution and will then be agitated by compressed air in both of the vats. Butters filters are to be employed for treating the residue. At Guanajuato there is similar activity. A 1,000-ton plant is assured for the La Luz mines. The plans call for 320 stamps, concentrators, regrinding machinery and a cyanide annex. Machinery for a 60-stamp mill and cyanide plant is reported to have been ordered for the Tajo de Dolores mine. The *Mining and Scientific Press* of June 29 contains an illustrated description of old and new methods at Guanajuato from the facile pen of T. A. Rickard.

Homestake Mills.—In *Mining and Scientific Press* of July 6, F. L. Bosqui gives an account of present cyanide practice at the Homestake Mills in South Dakota. There are six stamp mills containing an aggregate of 1,000 stamps and crushing about 4,000 tons per day. The most interesting feature of the mill practice is the amalgamation. Each battery is provided with four full-size plates, in series, each plate being 54 x 144 inches and ⅛ inch thick. The first is plain copper, the last three are silver-plated. This addition of three silver plates, giving to each 10 stamps of the Amicus (240-head) mill, a total plate area of 600 square feet, and to the other mills an average of 360 square feet per 10 stamps, is a comparatively recent innovation, and has proved an excellent one, increasing the recovery by amalgamation approximately $200,000 per year above the annual recovery when only one 12-foot plate was used. The saving by amalgamation is between 70 and 75 per cent. The leachable portion of the tailings is treated after slime separation at two cyanide plants. The most interesting feature is the treatment and filtration by means of filter processes as devised by C. W. Merrill. At the more recent of the two plants the total cost of treatment per ton during the last six months of 1906 was between 16.1 and 18 cents.

Slimes Filter.—In our March issue, page 88, we published a description of the Butters slimes filter. A very elaborate article on the filtration of slime by the Butters method is given in the *Mining and Scientific Press* of June 22 and 29 by Mr. E. M. Hamilton.

Ore Dressing.

Acid Flotation Processes.—In our Vol. IV., p. 49, we gave a review of acid flotation processes. In the *Mining and Scientific Press* of June 8, F. H. Jackson gives an illustrated account of the practice of the acid flotation process at Broken Hill. The object is to separate the blende from the gangue. The tailings from the lead concentrating mills consist of a mixed product of blende, garnet, quartz, rhodonite and calcite. Since the blende has practically the same specific gravity as rhodonite and garnet, no method based on gravity can be used. The Potter and Delprat patents are both for "acid notation" processes and both depend on the power of an acid solution to float the particles of zinc blende on its surface, from which they may be mechanically and continuously drawn off. Both processes are practically the same, and the same type of plant required for each, but while a weak acid solution is all that is required in Potter's method, the Delprat process requires the use of salt cake, which, it is claimed, increases the specific gravity of the solution, and therefore its floating powers. This salt cake is acid sodium sulphate ($NaHSO_4$), and is a by-product in the manufacture of sulphuric acid at the Proprietary Co.'s works. Whether it is of any material benefit is doubtful. The strength of the acid solution used depends on its temperature and on the alkalinity and freshness of the tailings treated; it varies from 0.5 to 1.5 per cent H_2CO_4. Very old tailings and those which have become oxidized, consume more acid than would be required to treat them

as they came from the lead concentrators in dissolving the incrustations from the faces of the blende particles before concentration by flotation can take place. The temperature of the solution is a most important factor, it should be kept as high as possible, and not lower than 80° C. Testing of solution in the pans for temperature and acidity should be frequent throughout the shift, the latter being tested by titration with normal sodium hydrate, using methyl orange as an indicator. Material between a 40-mesh and an 80-mesh screen was found to be the best in size for treatment, and old tailings should be sifted through coarse screens to extract stones and other rubbish, which cause trouble in the pans. What actually happens in the pans is a little obscure, but the following is an approximation: "The calcite and other carbonate particles in the tailing, together with the iron in the blende, are at once attacked by the acid, and bubbles of CO_2 and H_2S are respectively formed. For some reason the bubbles of CO_2 leave the calcite, etc., and attach themselves to the bubbles of H_2S surrounding the particles of blende, thereby causing these to float to the surface of the liquor; the flow of liquor carries the blende and bubbles into boxes, where, on the bursting of the bubbles, the blende particles sink and are drawn off. The quartz, rhodonite, etc., in the gangue sink to the bottom of the pan without hindrance and are tapped, the process being continuous." An illustrated description is then given of the practice in a Broken Hill mill using a powder process.

MISCELLANEOUS.

Coal and Oil Muffle Furnaces.—The *Mining and Scientific Press* of June 1 contains an article by G. J. Young, in which a coal and an oil muffle furnace were compared, which were identical in all dimensions with the exception of the two combustion chambers, the combustion chamber of the oil furnace being altered to admit of better flame distribution than could be obtained by using the coal combustion chambers. The main advantages of the oil furnace over the coal furnace, apart from the slight one of operating costs, are its cleanness, ease of regulation, the high temperature quickly reached and easily maintained and the moderate amount of attention required. The principal objection is the noise of the burners. Temperature curves given in the article show the difference between the combustion of the coal and and oil. With the coal furnace, combustion takes place throughout the combustion chamber, with the oil the combustion takes place principally in the lower part of the chamber. This accounts for the small difference of temperature (15° C.) between the upper and lower muffles in the coal-fired furnace and the greater difference (140° C.) in the case of the oil furnace. The relatively lower flue temperature of the oil furnace is due to the same cause.

Melting Points.—An American Physical Society paper by J. K. Clement, published in abstract in the June issue of the *Physical Review*, gives the results of some new measurements with the gas thermometer, a conscientious effort having been made to reduce the magnitude of the errors common to the well known European gas thermometers. The following results of melting point determinations are given:

Zinc, 418.4°, greatest deviation from the mean, ± 0.4
Silver, 957.5°, greatest deviation from the mean
Gold, 1,050.1°, greatest deviation from the mean
Copper, 1,080.2°, greatest deviation from the mean, ± 0.5°

The Detinning Suit.

Under the title "The Outcome of the Detinning Suit" we reported in our February issue, 1906 (Vol. IV., page 46), on the decision rendered by Vice-Chancellor Bergen, of the Court of Chancery of New Jersey, in the suit between the Vulcan Detinning Co. as complainant and the American Can Co. as defendant. This decision, which was in favor of the American Can Co., has now been reversed by the New Jersey Court of Errors and Appeals in a decision delivered by Judge Garrison on July 2.

On account of limitations of space we are unable to report at length on this decision, which is exceedingly interesting and important as a precedent with respect to the question to what extent so-called "secret processes" are protected. A full report is reserved for our next issue.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

ELECTRIC FURNACES.

Induction Furnace.—E. A. Colby, 859,641, July 9, 1907. Application filed Nov. 23, 1905. Assigned to American Electric Furnace Co.

A vertical cross-section of the furnace is shown in Fig. 1 and a horizontal cross section of part of it in Fig. 2. The annular crucible 1 with the chamber 2 for the charge rests on the base plate 3 of soapstone, and is provided with a jacket 4 with a wall of ashestos board and filled with magnesia for heat insulation. The magnetic circuit is represented by 6, 8, 9, 13, 14 and 18. A special construction is used to secure firm contact between the core 18 and the upper parts 13, 14, and at the same time to make it easy to detach these parts; 7 are the trunnions for tilting the furnace. Around the core 18 and within the annular ring 1, the primary winding 24 is provided, consisting of turns of copper tube through which water circu-

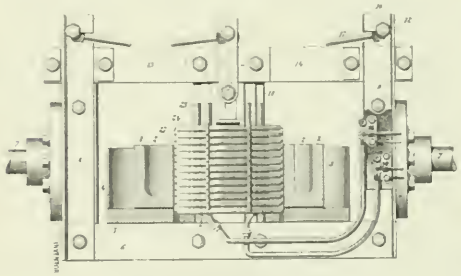


FIG. 1.—INDUCTION FURNACE.

lates for cooling. Interposed between the turns of the coil 24 are separating blocks 27 of refractory insulating material. As shown in the horizontal section, Fig. 2, the laminated core 18 is so constructed that vertical steep recesses are formed on its exterior. These recesses receive tubes 23 of porcelain fireclay, etc., which prevent contact of the core 18 and the primary core which surrounds it. There are 30 claims.

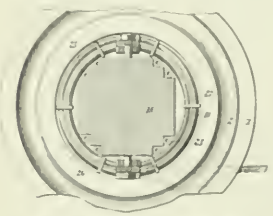


FIG. 2.—HORIZONTAL SECTION.

Production of Ferro-Silicon.—F. F. Price, 861,224, July 23, 1907. Application filed Aug. 31, 1904.

The furnace is provided with two electrodes suspended from the top and an arc is started between the electrodes and the carbon lining. A small amount of the charge is then fed into the bottom of the furnace, consisting of a mixture of silica, iron or iron ore, and coke, in which the ingredients are in such proportion as to make it a partial conductor when hot or which contains pieces of iron or magnetite and coke which tend to shunt the current. The furnace is then gradually filled until in its natural normal working condition the electrodes are

embedded in the charge. The minimum voltage is applied to the electrodes, to largely prevent the current from shunting through the charge. A layer of molten ferro-silicon collects in the bottom of the furnace. The high layer of charge surrounding the electrodes retains the heat within the furnace and protects the electrodes from the oxidizing and cooling effect of the atmosphere.

Manufacture of Silico Spiegel.—E. F. Price, 861,225, July 23, 1907. Application filed Nov. 14, 1905.

The process for making silico spiegel is quite analogous to that described in the preceding abstract for ferro-silicon. In the present case the charge consists of compounds of manganese and silicon and iron or iron ore together with carbon.

Detachable Hearth of Electric Furnace.—E. F. Price, 855,476, 855,477, 855,478, 855,479 and 855,480, all of June 4, 1907. Applications filed Nov. 14, 1905. 855,476 and 855,477 are assigned to Union Carbide Co.

In all these different patents the principal feature is that the electric furnace is provided with a detachable hearth or crucible which, when filled with the desired product, is withdrawn and an empty crucible is substituted. Preferably a series or chain of receptacles is employed to receive the product, each receptacle serving in turn as the hearth or crucible of the furnace; 855,476, 855,477 refer to the production of calcium carbide, 855,478 and 855,479 to the smelting of refractory ores and the production of ferro-alloys.

Vanadium and Alloys.—Fred. M. Becket, 858,325, June 25, 1907. Application filed June 19, 1906. Assigned to Electro Metallurgical Co.

To reduce vanadium from oxide and produce vanadium or vanadium alloys low in carbon, the inventor employs silicon and carbon as reducing agent, preferably in the combination of SiC. A basic flux such as slime is used to combine with any silica which may be present in the ore or concentrate, and with that derived from the oxidation of silicon. High yields are obtained of a product low in carbon, since the portions of the metal first reduced do not come into contact either with free silicon or free carbon, and therefore do not absorb the same to any injurious extent. The silicide of carbon and the ore are used in a fairly fine state of sub-division. To make ferro-vanadium or nickel vanadium, iron or nickel or their oxides are, of course, added to the charge.

Vanadium from Sulphide.—Fred. M. Becket, 858,328, June 25, 1907. Application filed March 5, 1907. Assigned to Electro Metallurgical Co.

The process avoids roasting and produces commercially pure metal directly from the sulphide. Commercially pure vanadium is produced by smelting in an electric furnace a mixture of vanadium sulphide and silicon or an alloy of silicon, the silicon being preferably employed in substantially the proportions required to combine with the sulphur of the sulphide or ore, the equation assuming the production of silicon sulphide, SiS_2. Commercially pure alloys of vanadium are produced by smelting in an electric furnace a mixture of vanadium sulphide with a silicon alloy, such as ferro-silicon or nickel-silicon, the alloy being preferably used in approximately the proportions required to supply sufficient silicon to unite with the sulphur of the sulphide or sulphide ore.

Reduction of Vanadium, Molybdenum, Titanium and Tungsten from Oxides.—Fred. M. Becket, 858,329, June 25, 1907. Application filed April 12, 1907. Assigned to Electro Metallurgical Co.

The process involves reduction in two stages. In the first stage partial reduction, specifically from a higher to a lower state of oxidation, is effected by a non-metallic reagent, such as carbon, hydrogen, carbon monoxide or a hydrocarbon; in the second stage the oxide is further reduced to a metal by silicon carbide. The first stage is carried out in an ordinary furnace, producer gas and water gas being particularly advantageous for this purpose. The second reduction is carried out in an electric furnace. In the case of vanadium the equation of the first stage is

$$V_2O_5 + 2C = V_2O_3 + 2CO,$$

and the equation of the second stage

$$V_2O_3 + SiC = V_2 + SiO_2 + CO.$$

The advantage of this combination process is that relatively inexpensive reducing agents are reduced in the first stage and the final reduction is effected by a relatively small amount of silicon carbide.

Low Carbon Metals or Alloys.—Fred. M. Becket, 858,780, July 2, 1907. Application filed Jan. 30, 1906. Assigned to Electro Metallurgical Co.

When the electric furnace is used for the production of low-carbon metals or alloys, aluminium or silicon may be used as reducing agent, but, nevertheless, some carbon will get into the metal, chiefly from the electrodes. To minimize this contamination the inventor contemplates the use of electrodes of very small sectional area. Since they have to carry a high current it is necessary to cool them in order to protect them. For this purpose a system of water cooling is used, as described and illustrated on page 279 of our July issue.

Alloy for Iron and Steel.—Fred. M. Becket, 858,327, June 25, 1907. Application filed March 20, 1907. Assigned to Electro Metallurgical Co.

The alloy which is stated to be particularly adapted for the treatment of iron and steel contains mainly titanium, calcium, aluminium and iron. The following two examples of the composition of alloys of this kind which the inventor has produced are given:

	Per Cent.	*Per Cent.*
Titanium	50.67	26.24
Calcium	8.32	5.30
Aluminium	22.70	1.55
Iron	11.83	50.98
Silicon	4.20	11.78
Carbon	1.86	3.69

The alloy is produced by reduction with carbon of a mixture of the oxides in the electric furnace. As compared with ferro-titanium the alloy possesses a relatively low melting point and is more rapidly incorporated with molten iron or steel and distributed through same.

Reducing Finely Divided Iron Oxides.—H. W. Lash, 860,922, July 23, 1907. Application filed Dec. 28, 1906.

As already noticed in our July issue, page 279, the process of the inventor contemplates the reduction in an electric furnace of a mixture of finely comminuted oxide of iron, such as iron sand or scale, with finely divided cast or pig iron and coke. Suitable iron oxide for treatment by this process are the sand ores of St. Lawrence and New Zealand, and their association with titanium oxide does not interfere with the process. Sawdust or crushed bituminous coal is a suitable addition, as are fluxes of the ordinary kind, such as lime and fluorspar. The following three mixtures are given as satisfactory for smelting:

	Mixture No. 1.	*Mixture No. 2.*	*Mixture No. 3.*
	Lbs.	*Lbs.*	*Lbs.*
Ore	16.00	12.00	18.00
Cast iron	16.00	6.00	7.00
Carbon	2.00	2.00	2.00
Limestone	.50	.25	.25
Fluorspar	.50	.25	.25
Sawdust	.50	.50	.50
	35.50	21.00	28.00

Electric Furnace.—Aldus C. Higgins, 856,061, June 4, 1907. Application filed April 6, 1906.

The object is to provide an electric furnace of relatively large capacity and so constructed as to permit the product to be formed and subsequently cooled under very uniform temperature conditions. For this purpose all the portions of the charge are brought within the cooling influence of cooled walls so as to secure commercial uniformity of the product. A relatively long and narrow furnace chamber is used in which are placed two rows of electrodes of opposite polarity at regular intervals. Between the two rows central interior walls are provided which are also cooled.

Electric Furnace for Pyritic Smelting.—H. Arden, 860,512 July 16, 1907. Application filed Sept. 24, 1906.

See the abstract under Pyritic Smelting in "Recent Metallurgical Patents."

Electric Zinc Furnace.—Fred. T. Snyder, 859,132, 859,133, 859,134, 859,135, 859,136, 859,137, all of July 2, 1907. Applications filed June 11, 1906, June 18, 1906, June 30, 1906, and July 25, 1906. Assigned to Electric Metals Co.

The principle which underlies all these patents is that in reducing zinc ore and condensing the zinc, liquid zinc will be obtained from fairly pure zinc vapor, but zinc dust from a zinc vapor diluted with other gases. Patent 859,132 (for the process) and 859,133 (for the apparatus) relate to the use of an electric furnace shown in Fig. 3. For the treatment of zinc lead ore, the ore is first roasted down to about 8 per cent in sulphur and the furnace charge is made up of the roasted ore mixed with coke or charcoal and with fluxes, such as lime and iron in such proportions as to form a slag which

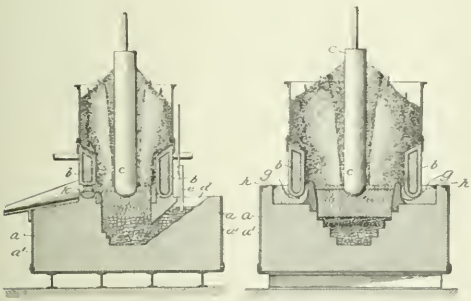


FIG. 3.—ELECTRIC ZINC FURNACE.

requires a high temperature for its formation. Such a slag will be high in lime and silica, the proportion of silica being about 50 per cent or more, and such a slag will not retain any appreciable quantity of zinc. The charge is fed into the rectangular stack furnace, being heaped up around the central electrode *c*, so that in general the coarser particles of the charge will roll toward the outside of the mass. Coke is also added around the outside of the electrode. The bottom of the crucible is filled with molten lead, forming the other electrode, connection being made to the outside to the conductor *e* dipping into the lead well *d*. A layer of slag rests on the molten lead and above the slag the charge of ore, etc. rests. The zone of maximum heat will be around the lower end of the electrode *c*, and the materials of the charge will there be reduced. The lead which is produced sinks to the bottom and adds to the body of the molten lead in the crucible, from which it may be ladled out from time to time through the lead well *d*. The slag which is formed is molten in the vicinity of the electrode, but around the hollow walls *b* which are water-cooled, the slag is congealed to form a lining for the walls. The CO gas which is formed escapes through the ore body to the top, where it may be burned. The conditions are such, however, that the escape of the gaseous product is restricted, so that a comparatively high pressure is maintained in a central portion of the ore body. Under such conditions the zinc is condensed in liquid form at the end walls *b*, and may be drained off under the walls through the wells *h*. The system of water-cooling the walls is so arranged that the greater volume of water flows through the end walls, so that there is a greater tendency for the zinc vapor to condense at the ends of the furnace than near the sides within the zone of maximum heat. The zinc vapor which attempts to escape with the CO gas upward becomes condensed in the ore body on account of its lower temperature and is condensed in the form of zinc dust. While the ore is progressively fed downward toward the heat zone, the zinc dust is again brought into the zone of maximum heat and revaporized, the result being that the mixture of gas in the furnace is progressively enriched until the percentage of zinc in the mixture is sufficiently high, so that the zinc condenses in liquid form in the wells *g*. The author states that, broadly, his invention involves heating the mixture to be smelted in successive stages; first to a temperature sufficient to reduce the compound, removing the non-metallic gaseous products of reduction at this stage through a free surface of the charge, while maintaining such free surface below the vaporization temperature of the volatile metal so as to prevent the escape thereof, and then at a subsequent stage subjecting the residue to an increased heat sufficient to fuse the same to slag and liberate said metal as vapor separate from the other gaseous products given off at the preceding stage.

Patent 859,134 relates to the use of the furnace shown in Fig. 4. It contains a smelting chamber *a*, and alongside of it a condenser *b* for liquid metal and the preheating chamber *c* to complete the roasting of the ore before it is fed into the smelting chamber through the opening *f*. The smelting furnace is an electric induction furnace, the charge, etc., surrounding the core *d*. In smelting lead-zinc ore, the furnace chamber contains molten lead in the two wells on either side, matte above the lead and slag above the matte, the slag ex-

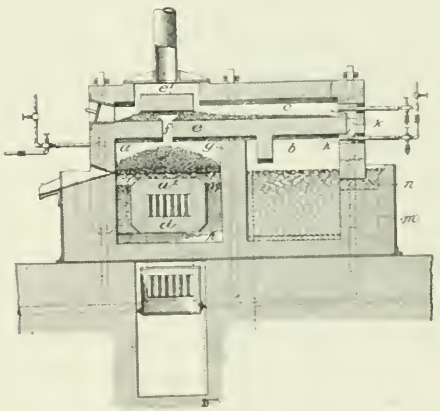


FIG. 4.—ELECTRIC INDUCTION FURNACE FOR ZINC PRODUCTION.

tending across the top of the bridge and electrically uniting the material in the two side wells. Above the slag the charge of ore is fed. When the charge has been introduced into the furnace the opening *f* is closed by means of the door *e*. The charge is now smelted in the absence of air, going through four stages of heating, the heat being applied at the bottom of the body of the charge and gradually spreading upwards, the portions nearest the slag being melted down first. During the first stage carbon monoxide is given off in considerable quantities with some zinc, but the upper portion of the charge is sufficiently cooled so that most of the zinc vapor liberated during this stage is condensed in or on the charge in the form

f dust which remains in the furnace chamber. After most of the CO gas been driven off, the second stage begins, in which the zinc vapor is given off freely, which is condensed in the chamber *b*. In the third stage the residues are fused to form slag and matte, and the fourth stage is that in which the fused charge is subjected to the maximum heat, the slag being superheated to expel substantially all the volatile metal. Patent 859,137 relates to essentially the same construction, but it also considers heating in a different way than by the induction principle, namely, by means of conductors dipping into wells which are in connection with the different molten baths in the compartments in a similar way as described above in the very first patent. (See also our Vol. IV., p. 319.)

Patent 859,135 (for the process) and 859,136 (for the apparatus) relate to the use of a furnace shown in vertical and horizontal cross-section in Figs. 5 and 6. It is operated by three-phase currents, three electrodes, 4, 5, 6, projecting vertically through the roof. In this case the purpose is not to produce directly liquid zinc but to produce first zinc dust, which is then resmelted into liquid zinc in another furnace. The electrodes are constructed of hollow carbon shells, which are filled with pulverized granular carbon feeding down through the hollow shells and resting on the slag bath underneath. The solid carbon shell does not touch the slag. The three flues 13 are provided for carrying off the gases due to reduction. Molten lead rests again on the bottom of the crucible. Above it there is a layer of slag and above that the charge is fed.

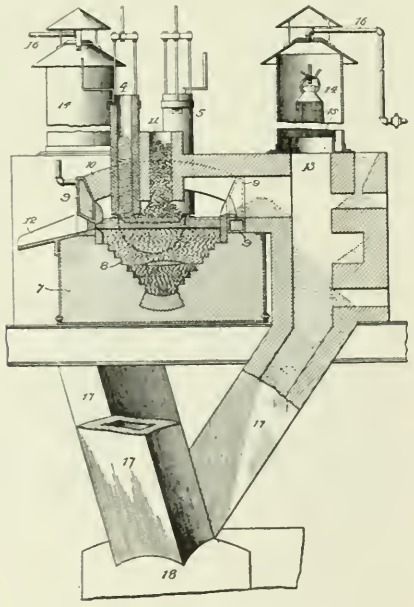


FIG. 5.—ZINC-DUST FURNACE.

The ores are first roasted down to about 6 per cent in sulphur and then mixed with fluxes, which will form a slag running about 40 per cent in silica, 30 per cent in lime and 15 per cent iron. Since the object is to get zinc dust, the charge is prepared so as to produce large quantities of other diluting gases, such as carbon monoxide. For this purpose the inventor adds to the ore a gaseous coal or limestone, and for the iron flux he uses iron carbonate (siderite), each of which will give off large amount of gases. He also wets the charge so as to get a considerable volume of steam. When the mixture is smelted in the furnace in the absence of air the metals are reduced and the excess of carbon serves to reduce the CO_2 to CO, to prevent the oxidation of the zinc dust produced. The lead sinks to the bottom of the crucible while the zinc volatilizes and passes off with the other dilute gases through the flues 13. The zinc vapors in these flues and in the stacks 14 are condensed in the form of zinc dust, which collects on the inside of the woolen bags 15 and generally throughout the flues, and then falls down to the bottom when the bags are shaken and passes through the flues 17 to the secondary furnace 18, where it is converted into spelter. The zinc dust produced by the first furnace is entirely protected from the air and retains as much of the original heat as possible when conveyed to the second furnace. The furnace charge is so regulated as to produce some metallic iron in the furnace. This may be done by having a large proportion of coal in addition to the amount of iron ore in the charge. The iron is reduced and floats on the molten lead, and its function is to decompose the zinc sulphide in the matte so that the matte is maintained as free as possible from zinc.

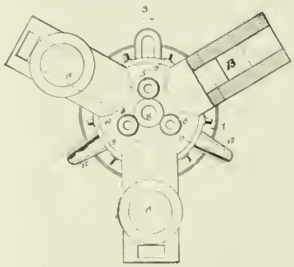


FIG. 6.—HORIZONTAL CROSS-SECTION OF FIG. 5.

Induction Furnace. J. Härden, 861,031, July 23, 1907. Application filed Jan. 24, 1907. Assigned to Gröndal-Kjellin Co., Ltd.

When in the past attempts have been made to use polyphase currents by providing one annular bath for each phase, such attempts have been unsuccessful, according to the inventor, on account of the great loss by heat radiation, which is given as about 9 kw. per square foot of the bath surface. Moreover, as the annular fusion chambers have to be placed at a considerable distance from the primary coil, an arrangement of two or three fusion chambers greatly increases the magnetic leakage in the transformer, thus causing a low-power factor and inefficient operation of the generating plant. "According to the present invention, polyphase alternating currents are employed in the working of electric induction furnaces by directly combining therewith one or more transformers to convert the polyphase currents of the supply mains into single-phase currents in the induction furnace." Diagrams are first given of feeding an induction furnace with two-phase currents, and then, by means of the well-known transformation of C. F. Scott from three-phase to two-phase supply the connections of an induction furnace to a three-phase supply are also shown. (To convert polyphase currents into single-phase simply by means of transformers, that is, without the aid of rotary machinery, is utterly impossible; see, for instance, C. P. Steinmetz, *Alternating Current Phenomena*, 3d edition, p. 460. It must therefore be concluded that with the arrangements shown in the patent the polyphase supply system must become unbalanced.)

Charging Electric Furnaces.—W. H. Huffman, 860,477, July 16, 1907. Application filed Feb. 15, 1907.

The object is to so charge an electric furnace of the Acheson type (graphite furnace) that a clear plane of demarcation is obtained between the furnace charge proper and the surrounding or embedding material. In charging the furnace some embedding material is first placed at the bottom and then longitudinal walls are built extending throughout the length of the furnace, so as to form a receptacle or channel for the charge. The charge is then filled in and the embedding material is filled in on the outside and the dividing walls are then withdrawn.

Electric Furnace.—Paul L. T. Héroult, 858,718, July 2, 1907. Application filed April 13, 1906. Assigned to the Soc. Electrometallurgique Française.

Details of construction of an electric furnace with one carbon electrode, the other terminal being formed by the carbon crucible itself. The construction is shown in vertical and horizontal cross-section in Fig. 7. The body A of the furnace is of carbon and bound by a surrounding jacket or rings of iron, steel or the like. The current passes from the electrode B through the charge and then through the cast iron piece C to the cable D. Ordinarily the jacket is made of iron or steel, forming a continuous ring of magnetic material so that a magnetic flux is set up within this ring. In order to eliminate it the iron portion E of the jacket is not continuous around the periphery, but is broken at one or more points the edges being connected by a strip F of copper or other non-magnetic material. This reduces very largely the impedance of the furnace when operated with alternating current. A more perfect contact than usual between the body of the furnace and the cast-iron base is secured by providing long forked pins H, which extend from the base upward into the carbon block and the lower ends of which are cast into the base plate C so as to make perfect contact therewith. For making a good connection between the cable D and the plate C a special contact block J of copper is provided, about which the plate C is so cast as to effect an intimate welded union.

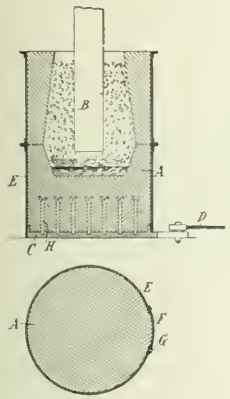


FIG. 7.—VERTICAL AND HORIZONTAL SECTION OF ELECTRIC FURNACE.

Electrodes for Electric Furnaces.—F. von Kügelen and G. O. Seward, 858,400, July 2, 1907. Application filed Jan. 31, 1905.

When carbon electrodes are used in electric furnaces it has been found impossible to prevent a portion of carbon from combining with the charge. Even if the electrodes plunge into the slag above the metal, carbon comes into the latter. The slag always contains oxides of the metal to be produced or refined, and these oxides are reduced by the carbon from the electrodes to a carbide which spoils the metal below. The present inventors use metallic electrodes which are water cooled. They describe the application of the process to the refining of ferro-chrome containing originally a high percentage of carbon—say 6 to 8 per cent. A crucible is made of carbon-free materials, such, for example, as chrome ore. The charge is made up of a refining slag of chrome ore and lime under which the metal to be refined is melted. The charge is first melted by temporary carbon electrodes. These are used for so short a time as to introduce only a negligible quantity of carbon. Then water-cooled steel pencils or electrodes are introduced into the molten charge. The temperature of that portion of the charge in contact with the pencil is reduced to a point so low that it will not materially attack or melt the pencil. The current passes from one pencil to the slag and thence to the other pencil and the metal at the bottom of the crucible is gradually refined by the action of the oxide slag on the carbon of the metal.

ELECTROLYTIC PROCESSES

Electrolytic Production of Sodium Oxide. C. F. Carrier, Jr., 859,431, July 9, 1907. Application filed June 9, 1906. Assigned to Elmira Electrochemical Co.

As now prepared, the oxides of sodium are made by the oxidation of previously produced metallic sodium. The object of the present process is to make them in one operation from sodium chloride. The cell for this purpose is shown in Fig. 8, the anodic compartment 7 being at the left and the cathodic compartment 15 at the right, both being in connection with each other through the layer of fused lead 30 at the bottom. The electrolyte 9 in the anode compartment is sodium chloride, the anodes 12 consisting of Acheson graphite. The electrolyte 17 in the cathodic compartment is fused sodium hydroxide with an oxidizing agent like sodium nitrate. By means of the burners 29 the furnace is heated to over 350° C., and lead is introduced into the pan to form a liquid seal at the bottom of the electrolytic compartment. After the electrolytes have been filled in and the circuit has been closed, the electrolytic decomposition of the sodium chloride in the compartment 7 results in chlorine being set free at the anode and carried off through the port 14, while simultaneously the sodium set free at the fused-lead cathode alloys with the lead. By means of the propeller

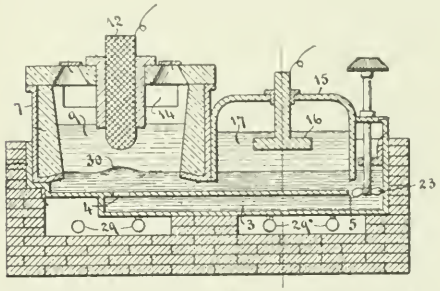


FIG. 8.—ELECTROLYTIC PRODUCTION OF SODIUM OXIDE.

23 a rapid circulation of the lead is produced through the two openings 4 and 5, by means of which the upper electrolytic compartments are in connection with the lower longitudinal compartment 3. In this way the sodium-lead alloy is carried away from the compartment 7 to the compartment 15, which is in form of a bell, completely closed except at the bottom. Here it acts as anode and sodium passes into the electrolyte NaOH. At the cathode 16 of nickel or iron, sodium would be set free if the electrolyte consisted simply of NaOH, but since it contains an oxidizing agent, sodium oxides are produced according to the following equations:

$$NaNO_3 + 3NaOH + 8Na = 6Na_2O + NH_3 \quad (I.)$$
$$NaNO_3 + 3NaOH + 2Na = 3Na_2O_2 + NH_3 \quad (II.)$$
$$Na_2O + \text{air} = Na_2O_2 + \text{nitrogen}.$$

Reactions I. and II. take place simultaneously, their relative preponderance depending upon the conditions of the operation. The product, as withdrawn from the cathode compartment, will contain both Na_2O and Na_2O_2. The Na_2O may be converted into Na_2O_2 by heating in an oxidizing atmosphere, air free from moisture and carbon dioxide being most suitable. Sodium nitrate is added from time to time.

Manufacture of Steel Dies. G. F. Diez, 857,920, June 25, 1907. Application filed Feb. 5, 1907.

The purpose is to produce steel dies directly from the object to be reproduced without the necessity of engraving the die. The method, therefore, consists essentially in depositing iron electrolytically directly upon the surface to be reproduced and then in so treating the iron matrix thus formed as to convert it into a grade of steel best suited for producing positive impressions in the material chosen for the copies of the original. The process is especially applicable to the reproduction of the finest type of engraving where faithfulness to the copy is important. The inventor produces upon the body to be copied a film of exceeding thinness, so fine and homogeneous in texture as to produce a deposit which from beginning to end is white like tin and at the same time so free from corrugations and

roughness or crystalline structure as to have the softness of silk to the touch. This is later converted into steel of any degree of hardness. The plating bath is made of 1,000 cubic centimeters of a saturated aqueous solution of iron sulphate and 125 cubic centimeters of a saturated aqueous solution of sodium bicarbonate (the sodium bicarbonate being added to the iron sulphate in two halves, the second half being added after 12 hours, and the solution being ready again 24 hours later). The anode is made of iron. A voltage of 0.7 to 1.5 is used, the density of the bath is 18° to 20° Baume and the temperature 21° C. The object to be coated is hung by a fine copper wire at a distance of 10 to 25 cm. from the anode. Under normal conditions a matrix thick enough for type or for seals to stamp on leather or paper can be obtained in from three to four days, depending on the dimensions, while a matrix to be attached to a block of steel and used as a die to stamp on metals will require from ten to fifteen days. In order to separate the deposited metal from the original or master, it is taken from the bath and washed with distilled water, after which, if the mold be metallic, the mold and matrix may be heated and may then be separated by inserting a thin blade between them and carefully prying them apart. If the original be of rubber, a slight heating will be sufficient, while when waxy compositions are used an immersion in boiling water is all that is necessary. In order to convert the soft iron matrix into steel of the required hardness the inventor takes charcoal powder 8 parts, steel filings 1¾ parts, potassium ferrocyanide ¼ part. To this mixture he adds a sufficient quantity of oil to form a paste. The several ingredients are all ground together in a mortar, and the oil is added in small quantities from time until the desired paste is formed. The crucible is half filled with the paste and the matrix is first wet with oil and then covered with powdered charcoal until a coating is formed thereon, and is then placed in the crucible with the matrix face down, after which the crucible is filled with the paste and pressed down and covered with plaster. The crucible is then placed in an oven and

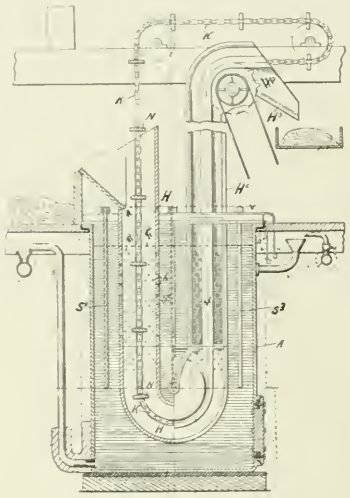


FIG. 9.—ELECTROLYTIC DETINNING APPARATUS.

maintained at a red heat from 8 to 10 hours, when the plate will be found to be converted into the finest steel, after which it may be tempered and is ready for use for stamping metals, and will stand the pressure of the most powerful presses.

Electrolytic Detinning.—M. Leitch, 859,565 (apparatus patent) and 859,566 (method patent), July 9, 1907. Application filed Feb. 17, 1906. Assigned to American Can Co.

The apparatus is about the same as described in the former patent of the inventor abstracted and illustrated on page 103 of our March issue. The object is to provide a continuous method of detinning in which all manual labor is eliminated except that required to feed the tin plate scrap into a hopper and collect the tin powder from the cathode plates. As shown in Fig. 9 the electrolytic tank A contains a U-shaped basket or tube H, the sides of which are perforated. Within this U-shape basket the tin scrap to be detinned is placed, and is moved down and up by means of the T-bars NN fastened to the conveyor chains K. As is indicated in the illustration the scrap is finally discharged through the chute H_3 into the washing tanks through which it is also carried automatically. The electrolyte is a solution of caustic soda heated to about 75° C., and three cathodes $S_1S_2S_3$ of iron are provided on which the tin is deposited in spongy form.

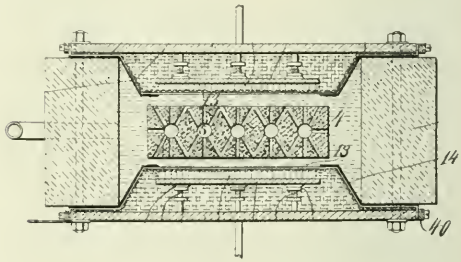


FIG. 10.—DIAPHRAGM CELL.

Detinning.—R. S. Wile, 859,792, July 9, 1907. Application filed Oct. 19, 1906.

The process consists of two steps, carried out in different vessels. The first step is the solution of the tin from the tin scrap by a purely chemical method, the second step is the electrolytic deposition of tin from the solution. The tin is removed from scrap of tine plate by a solution of 20 per cent of stannic chloride containing from 0.5 to 5 per cent of hydrochloric acid. By the absorption of the tin in the stannic chloride the latter is changed into stannous chloride. This process is carried out in an apparatus such as used for pickling sheet iron or steel. The stannous chloride solution is then run off into the electrolytic vat and electrolyzed with carbon anodes with a cathodic current density of 1 amp. per square inch. At the anode the stannous chloride is oxidized back to stannic chloride, while at the cathode tin is deposited in form of silvery white crystals. (In its principle the process is quite analogous to the old Hoepfner copper process.)

Diaphragm Cell for Sodium Chloride Electrolysis.—G. A. Gabriel, 12,672, July 16, 1907. Application filed May 29, 1906. Assigned to Bleach & Caustic Process Co.

This is a modification of the Hargreaves cell for the electrolytic production of chlorine and caustic soda. The general construction of the cell is shown in Fig. 10, representing a horizontal section. The Acheson graphite anodes 4 are provided with vertical and horizontal passages to permit thorough circulation of the electrolyte; 11 is a foraminous screen upon one side of which is placed the porous diaphragm 13. This screen 11 forms an active portion of the cathode. To restrict the active surface of the screen and diaphragm, the insulating material 14 is provided, consisting of heavy oiled silk, mica or hard vulcanized rubber. The outside of the screen 11 is provided with draining means to carry off the caustic soda formed, as was described and illustrated in our Vol. IV., page 322. Means for carrying off the products and controlling the level of the electrolyte in the anode compartment are also described. There are no less than 30 claims.

Cathode for Mercuric-Salt Solutions.—H. S. Hatfield, 860,657, July 23, 1907. Application filed Aug. 20, 1906.

As cathodes for the electrolysis of solutions containing mercuric salts, substances of the iridium group are recommended. The members of this group are iridium, tantalum, niobium, vanadium, silicon and magnetite. The inventor prefers iridium in the form of rolled sheet and hardened by sand blast.

Electrolytic Refining.—Anson G. Betts, 857,378, June 18, 1907. Application filed Feb. 20, 1905.

In electrolytically refining metals, such as copper, to which the anode residue does not ordinarily stick, the anode area in a tank finally becomes reduced while considerable anode copper still remains undissolved, thus increasing the anode current density, and in certain parts of the cathode surface the cathode current density. As the refinery contains a large number of tanks in the same electrical series it is not desirable to reduce the current passing for the sake of maintaining a proper current density in one or a few tanks to make pure copper, and as a consequence the anodes are removed from the tanks as scrap before they are well used up. Instead of this arrangement the inventor uses one or more shunts, with a switch for each, to shunt parts of the current around any undivided tank, or set of a few tanks, when the anode area becomes reduced. When the tank is first used the shunts are disconnected and the current entirely passes through the electrolyte. Toward the last, when the anode area begins to diminish considerably, a shunt is connected in circuit, and when only a small part of the anode surface is left all the shunts are used, when the electromotive force at the bus-bars is particularly the same as it was at first, and the small anode area remaining is undergoing electrolysis at the same rate as on the start. In refining metals, such as lead, containing 5 per cent of impurities, this process has the advantage that no copper, etc., will dissolve in the electrolyte which would happen if the current density and therefore the e. m. f. would become too high.

Nickel by Electrolysis.—H. H. Dow, W. S. Gates, A. E. Schaefer, 857,927, June 25, 1907. Application filed April 18, 1906. Assigned to Ontario Nickel Co., Ltd.

See the abstract of the patent relating to the recovery of nickel contained in basic nickel precipitates in the department "Recent Metallurgical Patents."

Batteries.

Battery Electrode.—T. A. Edison, 857,929, June 25, 1907. Application filed March 30, 1905. Assigned to Edison Storage Battery Co.

In the Edison iron-nickel storage battery the active mass of nickel hydroxide of the positive electrode is admixed with a flake-like conducting substance to reduce the resistance. Formerly flake graphite was used for this purpose. In course of a long time, however, flake graphite undergoes a change in its contact resistance and the capacity of the battery is diminished. Edison now uses flakes of a nickel-cobalt alloy containing, say, 60 per cent of cobalt and 40 per cent of nickel.

Battery.—F. A. Decker, 857,600, June 25, 1907. Application filed March 30, 1904. Assigned to Decker Electric Manufacturing Co.

The chief feature of this battery is the use of a fragmental zinc electrode, consisting of zinc balls, granular scrap or the like within a porous cup.

Battery.—F. A. Decker, 857,607, June 25, 1907. Application filed Jan. 16, 1906. Assigned to Decker Electric Manufacturing Co.

Means for conveniently and compactly connecting a number of cells together for facilitating the operations of filling and emptying them. Claim 11 specifies "a plurality of crates arranged in parallel with corresponding ends connected together, each crate having bottom strips of less width than the ends and side strips disposed at different elevations permitting juxtaposed side strips of joined crates to lie one above the other, in combination with a series of cells in each of said crates, and conduits secured to the bottoms of the envelopes of the cells and disposed on either side of the bottom strips thereof, the conduits communicating with the interiors of the respective cells."

Battery Containing-Cell.—G. H. Stout, 842,123, Jan. 22, 1907. Application filed Aug. 13, 1903.

Claim 1 specifies "a cell comprising a casing or cell proper having a series of slots or grooves on opposite sides, a series of elements received in said slots to form one electrode, and a plate arranged in the bottom of the cell to form the other electrode."

RECENT METALLURGICAL PATENTS

Copper.

Bessemerizing Copper Matte.—Under ordinary conditions, when the slag formed in the converter has combined with all of the iron present in the matte and has collected it with other metals and the silica, the slag is removed from the converter, and with whatever proportion of iron oxide or other oxidized metal it may contain, is returned to the reverberatory or blast furnace to be used as a flux. Richard L. Lloyd, of Cananea, Mexico (857,816 and 857,817, April 30, 1907), proposes to maintain the slag in the converter or return it thereto until such time as its acidity, or at least its power of collecting bases, is exhausted; in other words, until it is practically saturated with the oxides. When in this condition it is much more efficacious as a flux, and a considerable economy, (both in the converter and in the furnace) is secured in the use of the silicious ore, the expense of obtaining which for the reduction process is an important item in the cost of the refined copper. While in ordinary practice the moment of withdrawal of the slag is based on the condition of the copper matte, it is based in Mr. Lloyd's process on the ability of the slag itself to collect bases.

The process of Lloyd may best be seen from Fig. 1. A and A¹ are two feeding barrels, A being charged with copper matte and A¹ with the slag or flux. The mattes and the slag

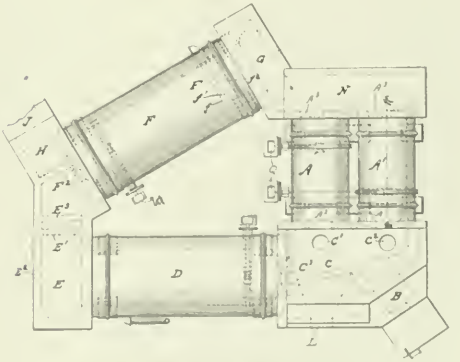


FIG. 1.—BESSEMERIZING COPPER MATTE.

are fed to the hearth C, and at B a furnace is shown which may be used in the initial operation of the plant to heat the materials and start the process. From the hearth C the matte and slag pass through the spout C' into the primary converter D, where the matte is fused and blown. The iron and other impurities go into the slag, while the copper sulphide settles to the bottom of the converter. From the converter D the slag and copper sulphide are discharged into the hearth E. A siphon dam, consisting of the wall E' with perforations at its

bottom, and an abutment E^2 higher than the perforations and beyond them, forms the outlet from the hearth E^1; while an opening E^3, a little higher than the abutment E^2 forms a slag outlet, the operation of the arrangement being such as to completely separate the copper sulphide from the slag. If the acidity of the slag be exhausted it may be at once returned to the furnace for use as a flux or otherwise disposed of, while if it is still acid it may be returned to the converter D through one of the openings C^1, C^2, in the hearth C. The copper sulphide passes by a suitable spout F^2 into the second converter F, where it is again subjected to blast and the remaining sulphur blown out of it. At the exit end of the second converter is a siphon dam formed of the wall f^1, having the perforations f^3 and the wall f^2. The copper being heavier than the copper sulphide sinks and passes through the perforations f^3 and over the wall f^2, while the copper sulphide is kept in the converter until the sulphur has been completely oxidized and driven off. From the converter F the copper passes into the hearth G, where it may be poled or otherwise further refined. The hearth E is impervious to the blast, which proceeds from the converter D through the feeding barrels A, A^1, the flue N and the hearth G (which is the coolest point in the operation) into the converter F, the flue H to the flue J, and thence to the stack. In this process the flow of copper sulphide from the first to the second converter, as well as the flow of metallic copper from the second converter into the hearth is practically continuous.

Pyritic Smelting.

Use of Electrically Heated Air.—In the pyritic smelting of ores which are deficient in sulphur so that the heat of oxidation is insufficient to maintain or complete the reaction, Henry Arden (890,512, July 16, 1907) endeavors to supply the deficiency with the aid of hot air heated in an electric furnace. This is a resistance furnace, the resistors being carbon bars coated with a refractory layer of carborundum, applied as a paint with sodium silicate as a binder. Another excellent resistor, particularly where currents of comparatively high voltage are employed, is said to be bars of carborundum consisting of grains bound by sodium silicate. Such resistors will not be oxidized by the air. It is also advantageous to introduce with the hot air a heavy hydrocarbon or the vapor of a hydrocarbon, the oxidation of which also supplies heat. The inventor vaporizes the hydrocarbon in an independent furnace, preferably in an electric resistance furnace, and conveys the vapors through the furnace employed for heating the air and thence into contact with the ore. The quantity of hydrocarbon vapors may be easily regulated by suitable automatic feed, to meet the two purposes of its introduction, viz.: to diminish the amount of oxygen under a given pressure of the blast or to increase the heat thereof.

Smelting Furnace.—Although not a system of pyritic smelting, the method of W. Kemp (846,216, March 5, 1907) may be mentioned here. The chief feature of the furnace is that the ore to be smelted is not mixed with the fuel. The ore chamber is longitudinal and situated in the center of the furnace. The fuel is introduced separately into two longitudinal fire places running at the bottom of the furnace on both sides of the ore chamber. The fuel is supplied with an up blast from the bottom and a down-blast from the top. It is fed cold into the fuel chambers and burns there in immediate contact with the ore. A blast is also introduced into the ore chamber above the fuel chambers. In the case of a sulphide ore much of the smelting heat is obtained from burning the sulphur. The chief saving of fuel is, however, due to the fact that no carbon monoxide can escape, as is the case if the carbon is mixed together with the ore. In the present case the carbon is completely burned to carbon dioxide.

Iron.

Blast Furnace Top.—C. H. Clark (857,158, June 18, 1907) proposes to remove as much as possible of the charging mechanism from the top of the furnace and to operate the mechanism with the aid of an endless cable and with suitable reducing gear directly from the hoisting engine, so that, for instance, the furnace top will turn one-quarter or any other desired fraction of a complete rotation during the lifting of a car of stock.

Charging Apparatus.—G. R. Johnson (853,010, May 7, 1907) wishes to do away with the old bell and hopper arrangement altogether and substitute a charging apparatus for which he specifies in claim 1 "the combination of a blast furnace, a revoluble spout extending into said blast furnace, a valve hinged to the lower end of the spout, chains connected with the valve, pipes carried by the spout through which said chains extend, means for operating the chains in a direction to close said valve to cause it to support a mass in the spout, said valve when opened serving to release said mass, and a second valve supported independently of the spout and closable against the upper end thereof above the mass therein and to constitute a seal for said spout."

Tuyeres.—J. W. MacDonald (860,983, July 23, 1907) refers to the disadvantages which result if in blast furnaces having a series of water-cooled metal jackets in their walls the tuyeres form part of the water jackets. He proposes to arrange the tuyeres in specially constructed water-cooled chambers independent of the metal jackets and designed to be separately removable from the furnace walls.

Agglomerating Blast Furnace Dust.—W. Schumacher (859,411, July 9, 1907) patents a binder for agglomerating blast furnace dust or other comminuted or pulverulent substances. Very finely ground silicious material is mixed with lime and with the substance to be agglomerated and then exposed to the action of steam under pressure. The best results are obtained if the silicious material and the lime are ground together so that the silicious material in being broken up will exert a grinding action on the lime and the small particles of silicious material will be covered with lime dust.

Flux.—J. Davies (858,582, July 2, 1907) recommends the following flux or "physic" for the treatment of pig iron: Charcoal 2/16 per cent, rock salt ¼ per cent, limestone 1/3 per cent, plumbago 3/32 per cent, soda 2/3 per cent, manganese ¼ per cent, nickel 6¼ per cent. The aggregate of these ingredients is nearly 8 per cent, the remaining 92 per cent being molten iron to which the flux is added. The effect is said to be that the impurities in the iron are eliminated, that the metal is free from slits and blow-holes and that it has a greater tensile strength and density.

Gold and Silver.

Pressure Filter.—In a pressure filter patented by A. E. Davis, of Johannesburg, Transvaal (859,749, July 9, 1907), a series of vertically disposed filter plates are arranged inside a receptacle into which the slimes or other material to be filtered are passed. The separation of the solid matter is effected by the deposition of the particles of solid matter on the superfices of the filtering cloth which covers the surfaces of said plates, the separated liquid flowing along grooves or flutes in the surfaces of the plates to a common outlet or delivery. The object of the construction of the filter plates is to facilitate the discharge of the separated solid matter. The filter plates are provided on both sides with parallel and vertical grooves, and are made to taper from the top to the bottom and are enclosed in the filtering cloth. With the object of preventing the settlement or deposition of solid matter on any portion of the filter plate adjacent to the sides or top of the filter, the sides or top of the filter plates are made with a non-filtering strip or ungrooved portion. When the liquid has been pressed into the grooves and drawn off into a delivery pipe, the solid matter remains outside. When the filter box is practically full with solid matter its bottom door is opened and water is pressed into the filter plates in the reverse direction to that of the previous filtering flow. The

solid cake is thereby pressed away from the cloth and the cake drops out of the box.

Filter.—Quite a similar construction is patented by W. T. Janney and G. H. Dern, of Mercur, Utah (857,467, June 18, 1907). Instead of filtering plates they employ, however, filtering sticks. They thus have a large number of small units, each of which can be readily repaired without interfering with any other unit. The filtering sticks are made of wood of conical or tapering form and provided with an annular series of longitudinal grooves. The stick is covered by a canvas bag and the liquid is separated from the solid either by suction from the inside of the filtering sticks or by pressure on the outside. The liquid is drawn off through the grooves in the filtering sticks. The dislodging of the cake from the canvas bags is easy on account of the tapering form of the sticks.

Chlorination Barrel.—W. J. Armbruster patents a chlorination barrel, the feature of which is the construction of the tube through which the chlorine gas is introduced into the barrel. Instead of using a stationary delivery pipe or goose-neck, he employs a revolving pipe having an intake-end fixed within an opening disposed about the axis of rotation of the barrel. The joint interposed between the stationary feed pipe and the hollow trunnion of the barrel (through which trunnion the fixed intake-end passes) is in the nature of a removable sleeve feathered to the feed pipe, and has one end in forcible, yet movable engagement with the adjacent end of the trunnion. One of the trunnions of the barrel is hollow, the passage therein receiving the fixed or intake-end of the chlorine delivery pipe p. The latter extends in the form of two branches, p' p'', disposed along the inner surface of the barrel, the branches being secured to the adjacent head of the barrel by means of straps 4. This disposition of the branches p' p'' prevents the pulp at any time from backing into the intake-end p. The outer end of the hollow trunnion in the present construction terminates in an enlarged circular head 5, whose outer face is provided with an annular groove for the reception of a correspondingly shaped ring 7 formed on the adjacent face of one of the terminal flanges 8 of a rotatable sleeve 9, feathered to move longitudinally along the adjacent end of the stationary supply or feed pipe 10.

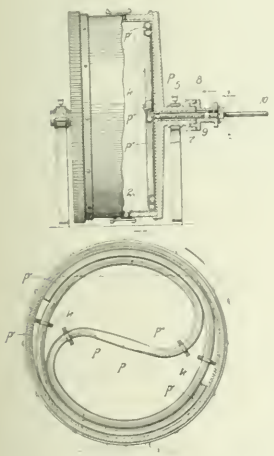


FIG. 2.—CHLORINATION BARREL.

NICKEL.

Treatment of Ores Containing Nickel, Copper, Cobalt and Iron.—A patent of R. W. E. MacIvor (859,770, July 9, 1907, assigned to Metals Extraction Corporation, Ltd.) relates to the treatment of ores containing nickel, whereby the latter metal is first concentrated into a matte or regulus which is afterwards subjected to a process of slow roasting to convert the metallic sulphides composing the matte into the corresponding sulphates. The method of forming the matte or regulus from the ore varies with the character and composition of the latter, but the agent employed is in every case sodium sulphide containing an excess of sulphur over the proportion contained in the normal sulphide Na_2S. In the case of sulphide arsenical ores a previous "dead" roast is essential in order to get rid of the arsenic, whereas with ores of the double silicate of nickel and magnesia type (garnierite) no preliminary roasting is necessary before mixing with the sodium sulphide. To carry out the operation of forming the matte the roasted or unroasted ore, as the case may be, is thoroughly mixed with from one-fourth to one-half its weight of the sulphide of sodium and not more than 5 per cent of carbon, preferably ground anthracite coal. This mixture is made into blocks or bricks with water, and after being dried sufficiently to allow of handling, they are smelted in a reverberatory furnace. The temperature is gradually raised to and maintained at the point of complete decomposition of the sulphate of iron present in the roasted mass, the sulphate of nickel and copper being left unaltered. These latter salts are obtained in solution by throwing the hot mass from the furnace into the water acidulated with sulphuric acid to an extent dependent upon the copper in the ore under treatment. This solution is allowed to settle, drawn off from the oxide of iron and other sedimentary matter and treated by known methods for the recovery of its copper contents. After the extraction of the copper the nickel and cobalt are precipitated from the solution by milk of magnesia or lime, or by soda, in the form of oxides, and these are collected and dealt with by known methods.

Nickel from Basic Nickel Precipitates.—When basic nickel precipitates, such as the hydrate and the carbonate, are treated with free halogens, such as chlorine and bromine, only a part of the nickel is dissolved to soluble haloids, and the balance remains insoluble, having been oxidized by the halogen to black nickelic hydrate. The latter remains insoluble unless it be dissolved in acid, or unless a very strong halogen be used. In the latter case some of the nickelic hydrate ($Ni_2O_3H_2$) may be dissolved, giving a dark-colored unstable solution, which readily decomposes upon standing or heating, thus giving off the halogen and reprecipitating the black nickel hydrate. The action of the halogen upon the nickel hydrate is as follows:

$$3Ni_2O_3H_2 + Cl_2 = NiCl_2 + 2Ni_2O_3H_2,$$

so that only one-third of the nickel is rendered soluble. In order to dissolve all of the nickel by means of a halogen some reducing agent must be present to prevent formation of the nickelic hydrate. H. H. Dow, W. S. Gates and A. E. Schaefer (857,927, June 25, 1907, assigned to Ontario Nickel Co., Ltd.) have found that either sulphur in the elementary state, preferably as ground flowers of sulphur, or in form of some compound like sulphur chloride serves the purpose very well. The reaction when the basic nickel precipitate is treated with free halogen in the presence of sulphur is as follows:

$$4Ni_2O_3H_2 + S + 3Cl_2 = 3NiCl_2 + NiSO_4 + 4H_2O.$$

Compounds of sulphur act in a similar way, but in whatever form sulphur may be employed the nickel obtained by this method is a mixture of chlorides and sulphates, and if it is intended to win the nickel afterwards by electrolysis with carbon anodes it is necessary to remove the nickel sulphates, since the carbon anodes would be destroyed. This is possible in one of the following two ways, either by the addition of $Ca(OH)_2$, when the halogen is acting on the nickel precipitate in the presence of sulphur, or by the addition of the proper amount of calcium chloride or calcium bromide with a subsequent precipitation of calcium sulphate. In the electrolysis the halogen, for instance, bromine, is set free at the anode, while simultaneously nickel is deposited on the cathode. The bromine is then returned to the dissolving apparatus, where it acts upon more basic nickel precipitate in the presence of sulphur, etc.

TIN.

Removal of Iron.—H. Brandenburg (859,504, July 9, 1907) patents a process for separating the iron and tin contained in the intermediate products of the treatment of tin ore, that is to say, in waste products, residues, tin containing slag, ashes,

scrap, soot and the like. The waste products, etc., are smelted with silicate of tin in presence of a basic flux. The silicate of tin is either specially prepared for the purpose or is obtained from the slags produced during the extraction of tin by former processes. The result is that the tin—both of the waste products and of the silicate—appears in metallic state, while the iron combines with the silicate. Any oxide or dioxide of tin that may be dissolved in the slag reacts in a similar manner.

Smelting Process.—H. Brandenburg (859,184, July 2, 1907) remarks that the reduction of tin ore in a smelting furnace with the formation of slag has the disadvantage that dioxide and oxide of tin dissolve in the slag, from which they can be extracted only with difficulty and expense. He recommends to prevent the oxide and dioxide of tin from passing into the slag by effecting the reduction at temperatures which preclude the possibility of the formation of any slag. The reducing process in such case takes place in such a manner that metallic raw or unrefined tin is obtained embedded in the loose, and not slagged, silica of the ore.

Detinning.—See abstracts in Analysis of Current Electrochemical Patents in this issue.

Zinc.

Charging Retorts.—L. W. Kirk (857,074, June 18, 1907) patents a machine for charging retorts which consists essentially of an injector tube *a* of metal through which the comminued charging material is forced into the retorts, a hopper *d* connected with the tube for supplying the charge, and a nozzle *c* connected with the tube and delivering a jet of steam or air behind the material discharged from the hopper into the tube. The material is thereby forced in a compact stream into the body of the retort, and at the same time the material is drawn from the hopper into the tube by reason of the injector-like action of the jet.

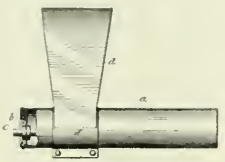


FIG. 3.—MACHINE FOR CHARGING RETORTS.

Electric Zinc Furnace.—See a number of recent patents granted to Fred. T. Snyder and abstracted in the Analysis of Current Electrochemical Patents in our present issue.

Roasting.

Chloridizing Roasting.—Refractory ores are subjected to a chloridizing roast according to R. McKnight (858,667, July 2, 1907) as follows: An intimate mixture is made of the ore to be roasted with salt, the ore being reduced to about 30-mesh. Practically salt to about 10 per cent of ore is added. The mixture is roasted with agitation in a revolving cylinder, and there subjected to a large and continuous supply of superheated oxygen-containing gas, such as steam or air, having a temperature of about 500° C. without any outside source of heat. The superheated air or steam is introduced as a large jet or blast. With a refractory ore containing zinc sulphide, lead sulphide, iron pyrites and silica, the following reactions are said to take place:

(1) $ZnS + 2O_2 = ZnSO_4$.
(2) $ZnSO_4 + 2NaCl = Na_2SO_4 + ZnCl_2$.
(3) $PbS + 2O_2 = PbSO_4$.
(4) $PbSO_4 + 2NaCl = PbCl_2 + Na_2SO_4$.
(5) $4FeS_2 + 15O_2 + 2H_2O + 16NaCl = 4FeCl_3 + 4HCl + 8Na_2SO_4$.
(6) $4FeCl_2 + 3O_2 = 2Fe_2O_3 + 6Cl_2$.
(7) $4NaCl + 2SiO_2 + O_2 = 2NaSiO_3 + 2Cl_2$.
(8) $2Au + 3Cl_2 = 2AuCl_3$.

Reactions 1, 3, 5, 7 are primary; 2, 4, 6, 8 are secondary.

When the ore is removed from the roasting furnace it is passed into a suitable amalgamator while it is still hot.

Magnetic Roasting.—In what is known as a magnetic roast the ore is brought into such a condition that it may be afterwards easily separated by magnetic concentration into magnetic and non-magnetic material. A difficulty which has been experienced in such processes has been due to too high a temperature, whereby the ore particles have been brought into slightly fused condition so as to cling together. The magnetic material is thereby contaminated and the object of the roast is neutralized. A. R. Wilfley (859,420, July 9, 1907) roasts such ore by causing it to travel downward by a current of hot air instead of in opposite direction to such a current as is the usual custom. The roasting furnace is shown in Fig. 4. Hot air produced on the fire-box of the right-hand compartment passes upward, around the top of the dividing wall downward, together with the finely divided ore introduced through the top of the furnace. The course of the hot air is indicated by the arrows. When the roasted ores come down they drop on the water-cooled portion 15, 16 being composed of fire-clay and 17 and 19 being also water-cooled portions. The particles of the ore are thereby cooled so that the magnetic and non-magnetic particles will not stick together; they fall into vibrating trough 21, which is also water jacketed. Provision is made for imparting a longitudinal reciprocating movement to the trough whereby the roasted ore is caused to travel out of the furnace.

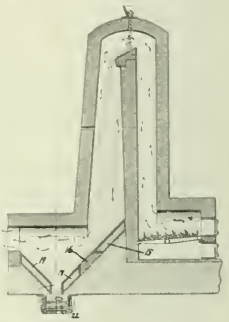


FIG. 4.—ROASTING FURNACE.

Aluminothermic Process.

Production of Manganese.—In the well-known Goldschmidt process as carried out heretofore the manganese compound Mn_3O_4, representing the lowest state of oxidation, is reduced by means of aluminium to metallic manganese. However, on account of the slow process, the output is comparatively small. It has now been found by Dr. Hans Goldschmidt and Dr. O. Weil (860,799, July 23, 1907) that a far better output up to 90 per cent and more may be obtained by adding to the Mn_3O_4 a relatively small quantity of a higher oxide, such as Mn_2O_3 of MnO_2. In general, very satisfactory separation of the manganese takes place if there is used a mixture of manganese compounds containing about 8 per cent of active oxygen (that is only 1 per cent more than in Mn_3O_4). A suitable mixture for the manufacture of manganese is the following: 73 kilograms of Mn_3O_4 and 5 kilograms MnO_2, both in the form of a powder, and 22 kilograms finely granulated or powdered aluminium are mixed and then ignited. When the process of reduction takes place new masses of the mixture are added, as already known in the Goldschmidt process.

Production of Boron.—K. A. Kuehne (861,129, July 23, 1907) states that those metals or alloys which cannot be produced or isolated separately in reguline form by the simple aluminothermic process can be reduced by aluminium and chlorate of potassium without the application of external heat. For instance, for the production of boron a mixture is prepared of two parts of finely divided aluminium, 5 parts of chlorate of potassium and 3 parts of a comopund of boron. The mixture is placed in a crucible and ignited by touching it with a red-hot iron rod or a strip of magnesia. The mixture begins to burn and melts together at a white heat into a thin liquid boiling mass, which consists, after cooling, of two easily separated layers. The upper layer consists of melted clay, sometimes set or stiffened with crystals, while the lower layer consists of a regulus of aluminium, which contains crystallized boron. The boron is then isolated by dissolving the aluminium in dilute acid.

Lead-Lined Hose

A flexible metallic hose which should find considerable application in chemical and metallurgical works and in allied industries, is being manufactured under the trade name of "Nyflexmet."

This hose is of unusual construction, being built of spirally twisted ribbon-like strips of pliable steel or copper. The edges are formed into interlocking lips, the joints of which are packed with asbestos or rubber. The result is that the hose, while obviously very strong, is yet flexible and capable of standing high pressures. The hose may be lined and also covered with lead, which is pressed into the spiral grooves, and forms an intimate metallic union between casing, core and body. This lead lining and outer casing protect the main structure from corrosion by moisture or acids, thus making the hose acid proof, with the great advantage of being at the same time flexible. It is adaptable for conveying acids, chemicals and acid liquors which would quickly attack other materials. This hose may be used in chemical and metallurgical works, refineries, paper mills, gas plants and dye works, and for conveying liquids under heavy pressures. Foaming and viscous alkalies are claimed not to injure it.

FLEXIBLE LEAD-LINED HOSE

Another important application may be found in carrying ammonia and anhydride under the high pressures used in refrigerating machinery, etc. It is claimed that owing to the construction of the hose it will stand rough usage and the freezing of any liquid in the hose will not cause it to crack.

The adjoining illustration shows a section, the method of construction, lining and covering. This hose is manufactured in all sizes from $\frac{1}{8}$ inch up to 12 inches internal diameter and any desired length. The couplings used correspond with the regular United States standard fittings, and are claimed to make a joint as strong as the hose itself.

The construction enables its use as a self-supporting pipe line, where supports or uprights cannot be placed near together, such as for crossing wide roads, chasms, etc., and in mines. It is claimed that a pipe 2 inches in diameter can be stretched 300 feet without support. The "Nyflexmet" hose is manufactured by the New York Flexible Metallic Hose & Tubing Co., 170 Lafayette Street, New York City.

Cold Galvanizing.

Galvanizing or coating with zinc is still carried out in this country mostly by the hot process by dipping or wiping, but in recent years a strong tendency has become manifest in favor of the "cold process," that is, zinc plating by electrolysis. The reasons are twofold. First, the superior qualities of electrolytic zinc coatings are now better understood. Second, the cost of the electrolytic process has been very largely reduced by the invention of suitable special devices.

Galvanizing by the hot process has the disadvantage that the coating is uneven and that therefore exaggerated quantities of zinc are required if the coating shall have at any point a certain maximum thickness. It is true that by the introduction of the wiping process the amount of zinc required has been reduced, but this has been done at the expense of the quality of the deposit. While the finished coatings certainly look well, yet in practice they are not found to be a protection against corrosion. This simply means that coatings obtained by the hot process must have a certain thickness if they shall be effective.

It is all wrong to believe that any zinc coating on an iron surface will afford protection, however it is applied. The looks of a zinc coating do not prove anything. If one were to study with the eye the quality of the coating it would be necessary to observe with the microscope the connection between the iron and the zinc. The quality of the coating depends essentially on the molecular joint or weld, so to speak, between the iron and the zinc, and it is for this reason that the method by which the zinc is put onto the iron is of enormous importance, as has been repeatedly pointed out in our columns.

We may refer especially to the extended researches of Prof. Charles F. Burgess, who proved conclusively a great superiority of electrolytic coatings over hot-process coatings with respect to adherence of the coating to the iron, its toughness and strength and resistance against chemical effects from the atmosphere. Prof. Burgess' results have been fully confirmed by independent investigators in Europe, so that there can be no longer any doubt that an electrolytic coating, even when thinner affords better protection than a coating obtained by the hot process. A further advantage is that with electrolysis it is easy to obtain a uniform coating all over the surface if only the arrangements are properly made, and by adjustment of the current and of the time of electrolysis the coating may be made of any desired thickness.

The chief drawback which has held back the progress of the cold galvanizing process on a large commercial scale has been the prevailing idea that the process is too expensive. Now, as a matter of fact, if the process is carried out in a way in which

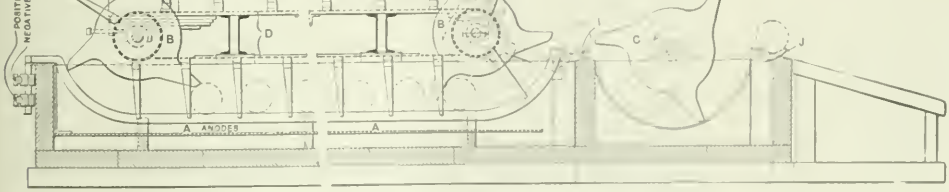


FIG. 1.—AUTOMATIC BAR IRON AND PIPE GALVANIZING APPARATUS

some of the old- fashioned electroplaters still do their work, the cost is high. But this is not the fault of the process but the fault of the people who apply old-fashioned manufacturing methods to a modern process.

By introducing modern manufacturing methods—that is essentially by devising special labor-saving machinery—the cost of cold galvanizing can be largely reduced and has been reduced. It is clear that the new process dispenses with the employment of the dross and skinning men, and there is no attendant required to keep the pots hot all through the 24 hours. On the other hand, it is evident that to obtain the highest economy with the new process new devices of handling different materials had to be invented, and these devices must differ in their construction according to the character of the material to be treated.

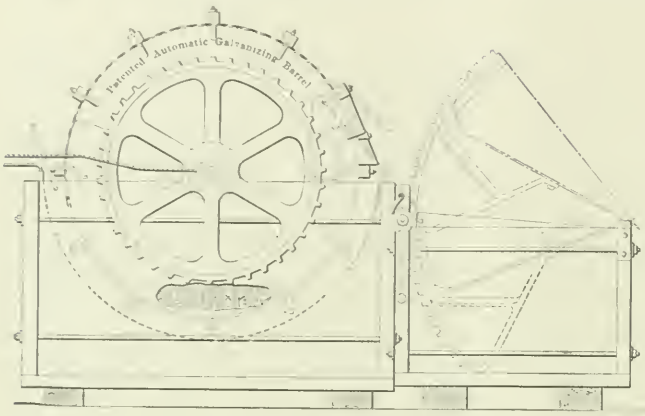


FIG. 2.—BARREL FOR GALVANIZING SMALL ARTICLES.

In this field the United Electro Galvanizing Co., of Brooklyn, N. Y., and its president, Mr. Louis Potthoff, have done important pioneer work. In the following some devices invented by Mr. Potthoff and now employed on a large scale are described:

Bar-Iron and Pipe-Galvanizing Apparatus.

The apparatus is suitable for the treatment of all long material from 6 inches up to bar-iron or pipes 20 feet or longer. Pipe can be coated inside and outside or outside only and sheet metal may also be coated in the same apparatus. The advantages claimed for this apparatus are that the coating is perfectly smooth, that the cost is less than half that of hot galvanizing, and that no experienced labor is required, since the apparatus works perfectly automatically and continuously.

Fig. 1 is a longitudinal section of the apparatus, showing two wooden tanks; the larger one, at the left, containing the galvanizing solution, and the smaller one, at the right, containing hot wash water. Two endless chains D are provided with which are connected pins of non-conducting material. The three-arm cast iron carriers B at the two ends of the tank introduce and discharge the pipes (indicated by dotted lines), and the pins push the pipes along through the tank on two copper bars connected to the negative pole, so that the pipes form the cathodes and are plated with zinc. These runways in the galvanizing tank slant so that the point of contact is constantly changing and an even coating is deposited on the pipes. The anodes are indicated by A.

The operation is obviously continuous. The tank is constantly kept filled, and while one pipe or bar drops out on the right-hand another one enters on the left-hand. By increasing or reducing the speed the thickness of the coating is increased or reduced. The thickness of the coating may also be increased if the length of the tank is increased. When a pipe arrives at the right end it pauses for a moment just before being finally discharged. It then passes over into the wash tank filled with hot water and provided with a three-arm carrier C, which pushes the pipes finally over to the place J, from where it is discharged out of the apparatus. The capacity of one tank, as constructed by the United States Electro Galvanizing Co., ranges from 3 to 6 tons per 10 hours.

Barrel for Plating Small Articles.

The apparatus shown in Fig. 2 is suitable for galvanizing all classes of small material, such as nails, screws, bolts, nuts, small castings, stampings, etc. The cut shows the latest improved form patented by Mr. Potthoff. The galvanizing barrel is again shown at the left and the washing tank at the right, the small articles being charged into the barrel at the left, and being discharged into the washing tank through the door

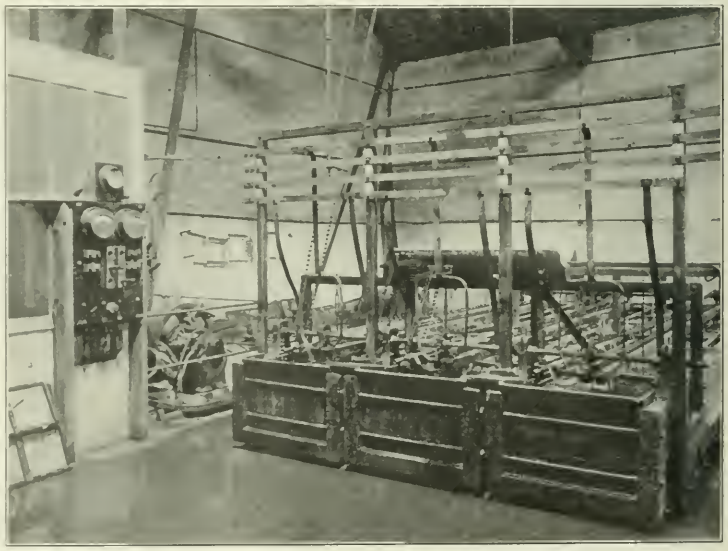


FIG. 3.—INTERIOR OF COLD GALVANIZING PLANT.

ordinarily closed by springs clearly shown in the illustration. While the material is in the tank it is thoroughly agitated so that a uniform coating on all parts of the little articles is obtained. The wash tank may be raised and lowered according to circumstances so as to keep the material sufficient time in the water and finally to discharge it. Mr. Potthoff states that the cost of galvanizing is from 30 to 50 cents per hundred pounds. The thickness of coating can be regulated at will. Bolts do not require rethreading. No skilled labor is required, since on account of the automatic action of the barrel the coating is smooth, bright and perfect and does not depend on the operator. The capacity of the barrel built by the United States Electro Galvanizing Co. is from 150 to 200 pounds to one filling, the output per day being 2,000 to 3,000 pounds.

Figs. 3 and 4 give interior views of an English cold-galvanizing plant in which automatic appliances similar to those described above are employed.

Hard Lead Exhaust Fans.

The use of exhaust fans for removing acid gases and for conveying gases in chemical works and metallurgical plants are numerous.

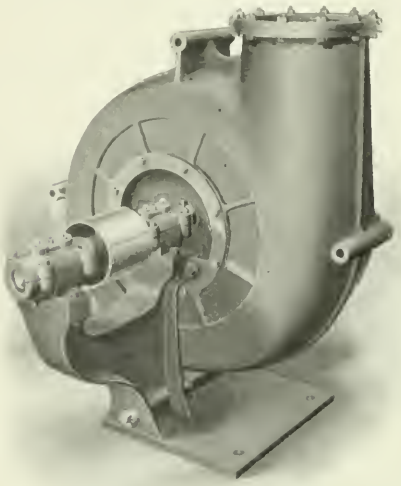
Where gases are encountered which would corrode iron and steel it has been customary to line the body of the fan with an enamel or glass, but still more often to use a stoneware fan.

The Schutte & Koerting Co., of Philadelphia, are now constructing fans built entirely of hard lead with the exception of the shaft, which is lead covered.

This material is very strong and fans constructed of it can be run at high speed.

These hard-lead exhaust fans are finding use in sulphuric acid plants, and may be placed between the glover tower and the first chamber, or between two Gay-Lussac towers where these are used, or at the end of the system, as circumstances may demand. The fan insures continuous draught under all conditions, resulting in economy of operation, the increased production often being 15 to 20 per cent without changing the burners.

The fan may be set to discharge vertically either top or bottom, or horizontally in either direction. When intended to run at low speeds the bearings are massive and strong, being provided with self oiling devices. The standard type is arranged for belt drive but electric drive may be substituted if desirable.



EXHAUST FAN.

The adjoining illustration shows a fan of this type which the Schutte & Koerting Co. build in eight sizes, ranging in output from 730 to 6,800 cubic feet per minute, the horsepower required varying from .28 to 3.5.

Some idea of the work these fans will accomplish can be gathered from the fact that the largest size has a capacity of 6,800 cubic feet. This fan is operated at 450 r. p. m., the diameter of the inlet is 28 inches, and it is driven by a pulley 16 inches in diameter by 8 inches wide.

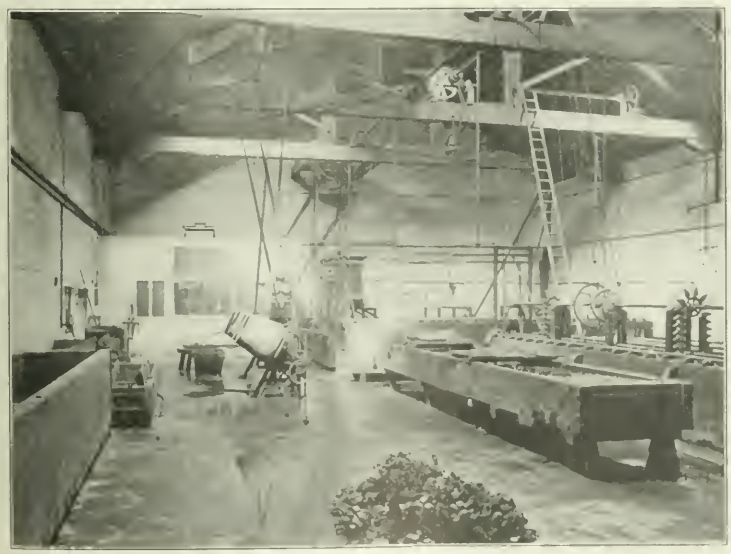


FIG. 4.—INTERIOR OF COLD GALVANIZING PLANT.

Sand-Lime Brick.—The manufacture of sand-lime brick is rapidly becoming an important industry in the United States and is likely to be as profitable here as it has been in Germany for the last ten years. A sand-lime brick is essentially a mass of sand cemented by hydrous lime silicates. The bricks can easily be made with a crushing strength of over 4,000 pounds per square inch and a tensile strength of over 200 pounds per square inch. A brick plant for making sand-lime bricks, near Sayreton, Ala., is briefly described in a paper by Charles Butts in the annual economic bulletin (No. 315) of the United States Geological Survey for the year 1906.

Automatic Still.

The adjoining illustrations show the construction of the automatic still built by the F. J. Stokes Machine Co., of Philadelphia. The raw water enters the lower end of the condenser, and in condensing the distilled water is heated to the boiling point by the time it reaches the overflow. A port connecting the still and condenser feeds this boiling water to the still and maintains a constant level, the action being therefore continuous.

The distinctive feature of this still is the manner in which the steam generated in the still is conducted down through the

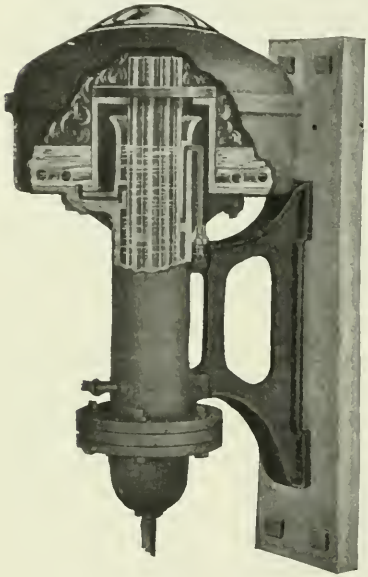


FIG. 1.—SECTIONAL VIEW OF STILL.

condenser, raising the temperature of the feed water to such a point that the ammonia gas is released and driven off. A further advantage of this preliminary boiling is that very little additional heat is required to vaporize it.

Either live steam or gas may be used for heating, and as the steam and water systems are entirely distinct, no oil from steam ever goes into the distilled water. All exposed iron surfaces are tinned to prevent corrosion.

An animal charcoal filter, through which the distilled water percolates on leaving the still, effectively removes all odor and gives the water sparkle and life. The still is made in four sizes for the treatment of 5, 10, 25 and 60 gallons per hour, respectively. The largest size is built in sections, and several stills of this size can be connected in series, thus increasing the total capacity to 300 gallons per hour for five stills in series.

Actual tests of the still of a capacity of 10 gallons per hour have shown that using steam equivalent to 100 pounds at a pressure of 15 pounds, and 125 gallons of condensing water, 10 gallons of distilled water were produced in 1 hour, showing that only 12 gallons of water are required for condensing, which is a very low value.

Notes.

Concentration Mills and Machinery.—A catalog of 92 pages with this title has recently been issued by the Colorado Iron Works Company, of Denver. The book is introduced by a very well written chapter on the scope and fundamental principles of concentration, with a list of specific gravities. Then follow illustrated description of a great many types of crushing, pumping and concentrating machinery.

Cleaning Castings.—The increasing application of the method of cleaning castings by the sand-blast method is indicated by the fact that during the past eight months the Thomas W. Pangborn Co., foundry equipment specialists, have installed their sand-blast machinery in 88 plants, including grey iron shops, malleable shops, steel shops, brass shops and aluminium shops.

New Applications of Gas Producers.—The Industrial Gas Co., New York City, has recently contracted to furnish a 600-hp. Harvey anthracite gas producer to the Albany Chemical Co., where it will be used principally for heating rotary vats in connection with the preparation of chemicals, and also to operate a small gas engine. The equipment will include an updraft generator, an economizer for reheating air and generating steam for gas making, a wet scrubber for cooling

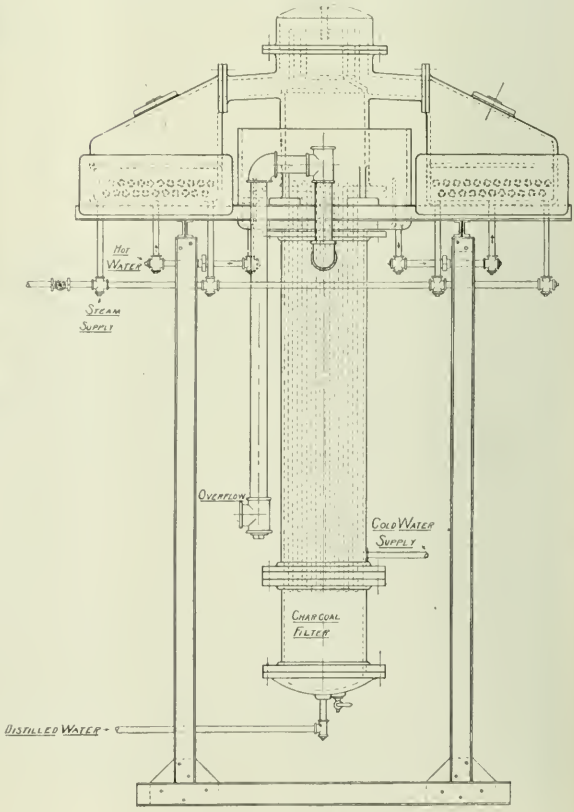


FIG. 2.—DIAGRAM OF AUTOMATIC STILL.

and cleaning the gas and a dry scrubber for drying it. This installation is principally interesting because it is the first in connection with this class of work in the chemical industries. The same company will install eight 12-ft. Herrick generators

for raw bituminous producer gas, to be used in connection with glass melting, at the works of the American Window Glass Co., Hartford City, Ind., eight for Jeanette, Pa. and thirteen for Arnold, Pa.

Electric Motors in a Rolling Mill.—The now celebrated order for 150,000 tons of steel rails placed by the Harriman lines with the Tennessee Coal & Iron Co., for delivery after March, 1908, has forced the latter company to extend its works, in order to handle its greatly increased business. The Tennessee Coal & Iron Co. has just placed an order with the Crocker-Wheeler Co., of Ampere, N. J., for the complete electric motor equipment of its new steel rail mill at Birmingham, Ala. The order includes fifteen Crocker-Wheeler form W rolling mill motors. The line of form W motors is designed for the ardous service of rolling mills, and has attracted very favorable attention in the steel world for its ruggedness and simplicity of design. The order aggregates about 575 hp.

Fire-Brick and Special Refractories.—The consolidation is announced of the Christy Fire-Clay Co. and the Laclede Fire-Brick Co., under the firm name of the Laclede-Christy Clay Products Co. Two plants are controlled and operated by this consolidation—the Christy plant and the Laclede—both situated at St. Louis, where the offices of the company will continue to be. The new company will continue to manufacture as heretofore the high-grade Christy and Laclede products. These include the standard fire-brick shapes of the various Laclede and Christy grades; silica brick in standard shapes and specials, linings for lime kilns, cupolas, brass furnaces, heating furnaces, rotary cement kilns, etc.; gas house refractories, sewer pipe and fittings, flue and chimney linings and tops, as well as special refractory materials to suit any requirements. The Laclede-Christy Co. are also engineers for gas houses, glass factories, coke ovens, plants and metallurgical works. Their products include a full line of fireclays and all clay products. The officers of the company are: William C. Morris, president; John L. Green, vice-president; Richard D. Hatton, secretary and treasurer. The superintendent of the Christy plant is J. A. W. Schoedel, and of the Laclede plant Frederick Talbot.

Electric Steel Furnace.—We have received from the American Electric Furnace Co.—which are the sole owners of the United States and Canadian rights to manufacture, lease or sell electric reduction furnaces under the patents of Colby, Kjellin and others—their well-illustrated pamphlet on the induction furnace. The principle of construction and operation is discussed and the general working arrangement of an induction furnace plant is given. A comparison with other methods is then made, especially with the crucible process and the open-hearth process. We use this opportunity to correct a misprint in the address of this company given in our last issue. The correct address is 45 Wall Street, New York City.

Power.—The American Gas & Electric Co., of Philadelphia, Pa., own and operate central station light and power plants in ten cities. They have special facilities and are enabled to quote attractive prices for power to electrochemical plants. They are backed by the General Electric Co., and their power plants are situated in the following cities: Atlantic City, N. J.; Scranton, Pa.; Altoona, Pa.; Marion, Ind.; Munsey, Ind.; Auburn, N. Y.; Conshohocken, Pa.; Canton, Ohio; Wheeling, W. Va.; Bridgeport, Ohio.; Rockford, Ill.

Electric Measuring Instruments.—We have received from the Leeds & Northrup Co., of Philadelphia, their exceedingly interesting and well illustrated 1907 catalog on electrical measuring instruments. After a brief review of the manufacturing facilities of the company, descriptions of the various electrical instruments made by them are given, and it should be acknowledged that, contrary to custom in trade catalogs, the descriptions in this one are quite specific in all cases, so that those who have occasion to consult the catalog may get definite ideas of the apparatus. Very considerable attention is also given to the illustration and description of details. Among the new instruments described for the first time in this catalog we notice a line of resistance thermometers. Since this is a subject of great interest to our readers, we will describe them at greater length in our next issue.

Maximum Results from Fuel.—A pamphlet has been issued by Prof. William Jones, chemist of the Metropolitan Street Railway Co., of New York City, on the chief requirements for obtaining the maximum results from fuel. Not only must the temperature in the flue be low, while that of the furnace is high, but the volume of the flue gas must be as small as possible. To attain this result it is necessary to allow only so much air to enter the furnace as is necessary for complete combustion of the fuel, that is the flue gas must not have any large excess of unused air, which excess is shown by the percentage of CO_2 in the flue gas. A diagram is given, showing at a glance the loss of fuel in flue gas as a function of the temperature and of the percentage of CO_2 in the gas. Prof. W. Jones has invented a gas analyzer which indicates continuously the amount of carbonic acid gas in the flue gas as it leaves the furnace.

Pyrometer.—We have received from Mr. Charles Engelhard, 41 Cortlandt Street, New York City, their latest pamphlet on the well-known Heraeus-Le Chatelier pyrometer. A brief description of the instrument is followed by a long list of plants in which it is in use in this country. Various useful tables of melting points, etc., are given at the end of the pamphlet.

Pyrometer.—One of the best and most clearly written discussions of the principles of radiation pyrometry may be found in the April issue of the *School of Mines Quarterly*, in an article by Messrs. C. H. Wilson and F. Maculen on the Féry radiation pyrometer. The description is so clear that it should be understood by anybody who is interested in the subject at all. The paper has been reprinted and copies of the reprints may be had from the Wilson-Maculen Co., 120 Liberty Street, New York City, for the asking.

Forged Steel Flanges.—We have received from the American Spiral Pipe Works, of Chicago, their 1907 flange catalog, containing a large amount of general and detailed information on flanges for power work. The catalog, which covers almost 100 pages, is profusely and exceedingly well illustrated.

Flange Union.—In endeavoring to devise a flange union which can always be made tight and remain so without the use of a gasket, the Western Tube Company, of Kewanee, Ill., has developed the "Kewanee" flange union which is made entirely of the highest grade malleable iron, excepting the brass seat, which is made practically integral with the malleable part by the only method which experience has shown to be enduring, by screwing in. There is no danger of breaking these malleable flanges in putting the joints together. The convex surface of malleable comes in contact with the concave surface of brass; this junction of hard and soft metal insures a more perfect seat than could be obtained otherwise and it makes no difference whether the alignment is straight or not.

Electrolytic Sterilization of Water in Swimming Baths.—Dr. Samuel Rideal, of London, has been permitted by the Westminster City Council, under protective conditions, to carry out experiments on the sterilization of water at one of the swimming baths by electrolytic chlorine, with the object of ascertaining whether the water need be changed as frequently when kept purified as at present.

Mining Machinery.—The John A. Traylor Machinery Co., of Denver, Col., have sent us their illustrated bulletins F and G, dealing with pumping machinery and with laboratory and sampling equipment, respectively. Bulletin F contains, besides illustrations of pumps, etc., some useful tables on the horse-

power required, the capacity and the cost of operating electrically-driven centrifugal pumps.

Gen. William J. Palmer has given the Engineering School of Colorado College, Colorado Springs, the sum of $12,000, to be expended immediately upon additional equipment of the engineering laboratories for senior work.

The Westinghouse Electric Works at East Pittsburg have established another new record by shipping during the month of May no less than 750 carloads of electrical machinery, or an average of thirty carloads a day, aggregating 10,000 tons, and representing in value about $4,000,000.

The Allis-Chalmers Co. states that the recent cry of dull times, raised by the various manufacturing interests of the country, finds no echo in their own business company which continues to show a steady gain. During the month of May this company shipped from its works 553 cars of machinery, which was a gain of 20 cars over the record established for April. In April the aggregate weight of shipments was 21,080,847 pounds, while for the months of May the figure has risen to 23,772,242 pounds, making a total by weight for the two months of 45,453,089 pounds. Cars bearing this enormous quantity of machinery, if coupled in one train, would have covered a distance of about eight miles.

Paint. Voltax liquid compound, which for the past year has been coming into extensive use as a weatherproof paint, has been specified by the Board of Education, of New York City, as a standard paint in Sec. 70, relating to painting and enameling on screens, radiators, coils and connections. Voltax will be used as a paint on pneumatic pipes, valves, canvas coverings on smoke pipes, grease extractors, economizer connections, feed water heaters, receiving tanks, boiler and incinerator fronts and on all fixtures, boilers, engines, pumps, blowers, foundations, steel bands and tanks set in the floors. To meet the growing demands for the compound the Electric Cable Co., of 17 Battery Place, New York City, is now erecting an extensive addition to their plant at Bridgeport, Conn.

The Electric Cable Co., of New York has just bought the entire business of the Eastern Wire & Cable Co., of Roxbury, Mass. The latter company is one of the oldest and largest manufacturers of rubber-covered wires and cables in New England. Its entire equipment will be removed to Bridgeport, Conn., where it will be installed in the plant of the Electric Cable Co., which has in course of construction a large addition to its plant.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

Calcium Carbid (*Continued.*)

No. 571,084, Nov. 10, 1896, Hilliary Eldridge, Daniel Johnson Clark and Mahlon W. Wambaugh, of Galveston, Tex.

Produces calcium sodic carbid containing a trace of borax by subjecting a mixture of pulverized quicklime, 72 bushels; carbon, 40 bushels; soda, 4 bushels, and borax, ⅛ bushel, to the fusing heat of an electric furnace. Common washing soda may be used. Both the carbonate of soda and borax should be preliminarily heated to expel water of crystallization; they are said to have an action on the lime "similar to a flux or an acid," greatly accelerating the reduction of the lime.

No. 572,036, Dec. 8, 1896, James Ellicott Hewes, of Philadelphia, Pa.

Produces carbid in a furnace having an inclined hearth of fire-brick. A hinged metal door, serving as the cathode, swings against the lower end of the hearth and closes the bottom of the angular chamber. The anode is a carbon slab sliding on the hearth and automatically fed. The product, smelted by an electric arc, is discharged through the opened door into a chamber beneath. The dust is drawn off through a lateral suction pipe, and the "ash, slag" and unreduced material passed downward through a screen to a conveyor.

No. 578,685, March 9, 1897, Edwin R. Whitney, of Manchester, N. H.

Springs crossing arcs between the ends of four radial horizontal electrodes consisting of powdered charcoal, forced through and out of tubes which terminate at the walls of the smelting chamber. A mixture of lime and carbon is fed downward through the arcs. The powdered charcoal is fed forward and caused to cohere by screw conveyors, but a binder of tar or syrup may be added. The liquid calcium carbid runs out of the smelting chamber through a grating at the bottom. The crossed arcs concentrate the heat and each arc counteracts the tendency of the other one to blow aside the particles of lime and carbon.

No. 583,498, June 1, 1897, James T. Morehead, of Spray, N. C.

Builds up an ingot of carbid in a rectangular smelting chamber, three walls of which consist of brick. The front wall consists of removable superposed sheets of iron, sliding in grooves. The lower electrode is a layer of carbon supported on a metal base plate. The upper electrode is an adjustable depending carbon rod. In starting the furnace, the lower iron sheet only, is put in place, and the enclosure is filled with pulverized lime 20 parts, and carbon 12 parts. When the charge has been converted into carbid the front wall is raised by putting another iron sheet in place, more material is charged in and reduction proceeds. When the furnace is filled with carbid, the front wall is removed and the unreduced charge around the ingot falls away and is used, while hot, as a new charge. The removal of the wall facilitates the cooling and removal of the carbid by grapples. By keeping the lower end of the upper electrode near the upper edge of the front wall the gases readily escape, without striking the electrode, prolonging its life.

No. 587,138, July 27, 1897, Isaiah L. Roberts, of Niagara Falls, N. Y.

Produces a continuous slab of carbid on a moving horizontal endless belt of wire cloth, each wire being covered with asbestos thread. Two horizontal electrodes passing through ball and socket joints, are arranged to spring an arc above the belt. The belt and electrodes are surrounded by a sheet iron casing, having an upper supply hopper at one end of the belt and a flue at the other end. As the arc effects reduction within the charge lying on the belt, the electrodes are gradually moved apart until parallel, the current passing through the slab of carbid, acting as a resistance. As the slab passes off the end of the belt it is gradually broken off in pieces, and the unreduced material falls into a receptacle and is returned to the hopper. The electrodes may be initially parallel and a current passed between them through pieces of broken carbon, constituting a temporary conductor until the bridge of carbid is formed. The process may be used for the production of carborundum or reduction of metallic oxids.

No. 587,509, Aug. 3, 1897, Isaiah L. Roberts, of Brooklyn, N. Y.

Produces a slab of carbid on an endless horizontal belt, an electric arc being sprung between the ends of transverse carbon rods, arranged over the belt. The belt and electrodes are arranged in a metal casing, provided with superposed supply hoppers at one end. The scraper shapes the charge as the belt carries it forward to the arc. An electromagnet deflects the arc downward onto the charge, producing flakes or scales of carbid, which are scooped off by a blade at the discharge end of the belt. The unreduced mixture falls onto a belt conveyor and is returned to the lower hopper. The belts are preferably of asbestos cloth. The whole chamber may be filled with a non-oxidizing atmosphere, for example, carbonic oxid or hydrogen.

NEW BOOKS.

Scientific Papers. By Josiah Willard Gibbs. 2 volumes 434 pages. Vol. I., $5.00; Vol. II., $4.00. New York City: Longmans, Green & Co.

Blast Furnace Calculations and Tables for Furnace Managers and Engineers. Containing rules and formulas for finding the dimensions and output capacity of any furnace, as well as the regular outfit of stoves, heating surface, volume of air, tuyere area, etc., per ton of iron per day of 24 hours. By John L. Stevenson. 44 pages. Price, $2.00. New York: D. Von Nostrand Co.

Open-Hearth Steel Castings. By W. M. Carr. 118 pages; 19 illustrations. Price, $1.50. Cleveland, Ohio: The Penton Publishing Co.

Practical Metal Turning. A handbook for engineers, technical students and amateurs (reissue of "Engineers' Turning"). By J. G. Horner. 404 pages; 485 illustrations. Price, $3.50. New York City: Norman W. Henley Publishing Co.

Gem Cutter's Craft. By Leopold Claremont 296 pages. Price, $5.00. New York City: The Macmillan Co.

Report on Progress of Investigations of Mineral Resources of Alaska in 1906 (United States Geological Survey Bulletin No 314). By Alfred Hulse Brooks and others. 235 pages; illustrated; paper binding. 30 cents. Washington, D. C.: Superintendent of Documents.

Practical Methods of Inorganic Chemistry. By F. M. Perkin. Price, $1.00. New York City: D. Van Nostrand Co.

Compressibilities of the Elements and Their Periodic Relations (Carnegie Institute Publications No. 76). By Theodore W. Richards. 67 pages; 8 illustrations Price, 50 cents. Carnegie Institute.

Further Researches Concerning the Atomic Weights of Potassium, Silver, Chlorine, Bromine, Nitrogen and Sulphur. By Theodore W. Richards, A. Staehler, G. S. Forbes, E. Mueller and G. Jones (Carnegie Institute Publications No. 69). 88 pages; 4 illustrations. Price, 50 cents. Carnegie Institute.

Industrial Alcohol. A practical manual on the production and use of alcohol for industrial purposes and for use as a heating agent, as an illuminant and as a source of motive power. By J. G. McIntosh. 252 pages; illustrated. Price, $3.00. New York City: D. Van Nostrand Co.

On the Absorption of Water Vapor of Certain Salts in Aqueous Solution by Quartz. By Lyman James Briggs. 26 pages; illustrated. Price, 25 cents. Ithaca, N. Y.: *Journal of Physical Chemistry.*

Practical Paper Making. A pamphlet for paper makers and owners and managers of paper mills, to which are appended useful tables, calculations, data, etc., with illustrations reproduced from Micro-Photographs. By George Clapperton 226 pages. Price, $2.50. New York: B. Van Nostrand & Co.

Different Methods of Purifying Water Read before the Engineers' Club of Philadelphia, Nov. 17, 1906. By J. A. P. Maignen. 67 pages; illustrated. Authorized reprint from Vol. XXIV, No. 1 (January, 1907), of the copyrighted proceedings of the Engineers' Club of Philadelphia.

Handbook on Engineering. The practical care and management of dynamos, motors, boilers, engines, pumps, inspirators and injectors, refrigerating machinery, hydraulic elevators, electric elevators, air compressors, rope transmission and all branches of steam engineering. Sixth edition revised and enlarged. 1,072 pages; illustrated by tables and diagrams. Bound in leather. Price, $3.50. St Louis: H. C. Tulley & Co.

Laboratory and Factory Tests in Electrical Engineering. By G. F. Sever and F. Townsend. Second edition revised and entirely rewritten; illustrated. Price, $2.50 New York City: D. Van Nostrand Co.

Modern Polyphase Machinery. By Andrew Stewart 296 pages; 181 illustrations. Price, $2.00. New York: D. Van Nostrand Co.

BOOK REVIEWS.

Commercial Organic Analysis. Vol. II., Part 3. Phenols, Aromatic Acids, Resins, Essential Oils By Alfred H. Allen, F. I. C., F. C. S. Third edition, rewritten and revised by the author and A. R. Tanhard, F. C. S. 8vo. pp. xi. + 547. Price, $5.00 net. Philadelphia: P. Blakiston's Son & Co.

This monumental work on organic analysis consists in reality of eight volumes, two of which have reached their second edition and five their third edition. The usefulness of these volumes to organic chemists can hardly be over-estimated. They give the properties, methods of valuing and proximate analytical examination of the various organic chemicals and products in practical use, together with the detection and determination of their impurities, adulterations and products of decomposition. The third edition of this particular volume is, moreover, not a mere reprint, for the chapters on resins and essential oils, forming nearly three-quarters of the book, are almost entirely new, occupying nearly ten times the space devoted to them in the previous editions. The ground is covered so exhaustively and the treatment is so clear and masterly, that this work must certainly become a *vade mecum* for everybody working with these organic compounds.

Alternating-Current Motors. By A. S. McAllister, Ph. D. 278 pages; 122 illustrations. Price, $3.00. New York: McGraw Publishing Co.

This is the first book ever published on the theory of alternating-current motors, including the single-phase commutator motors which are now becoming of such importance in electric traction schemes for main railways. There are sixteen chapters, dealing respectively with single-phase and polyphase circuits; outline of induction motor phenomena; observed performance of induction motor; induction motors as frequency changes; Heyland induction motor; single-phase induction motor; graphical treatment of induction motor phenomena; induction motors as asynchronous generators; transformer features of the induction motor; magnetic field in induction motors; synchronous motors and converters; electromagnetic torque; simplified treatment of single-phase commutator motors; motors of the repulsion type treated both graphically and algebraically; motors of the series type treated both graphically and algebraically; prevention of sparking in single-phase commutator motors.

Much attention is given to graphical diagrams and to examination of the facts upon which they are based. Mathematics is employed "merely as a short-hand method of stating facts." There is much truth in the following statement, which holds good for certain physico-chemical theories as well as for the analysis of alternating-current motors: "Beyond any doubt much confusion is created in the mind of an engineering student when an attempt is made to express certain *assumed* relations in the form of mathematical equations, and then to transform the equations to obtain a result which he is asked to believe expresses physical *facts* merely because the equations, considered mathematically, have been properly transformed."

The theory of alternating-current motors appears at first sight so very far away from anything which might interest electrochemists that the one point where both fields come in touch should be pointed out here. This is in the theory of the electric induction furnace which has now become a commercial apparatus for making high grade steel and which will become, presumably even more important for brass smelting. The induction furnace is a special case of a transformer. The induction motor is a special case of the general alternating-current transformer (with movable secondary). The theory of the induction motor is essentially based on that of the transformer; and many of the results can be taken over directly into the theory of the induction furnace. The induction motor and the induction furnace have this feature in common, which

STANDARD BOOKS

METALLURGY

ORE DRESSING
By ROBERT H. RICHARDS
Of the Massachusetts Institute of Technology
Two volumes, 6¾ x 9¾, cloth, 1250 pages, profusely illustrated, per set $10.00.

MODERN COPPER SMELTING
By EDWARD DYER PETERS
600 pages 6¾ x 9¾, cloth, $5.00.

PRINCIPLES OF COPPER SMELTING
By EDWARD DYER PETERS
Professor of Metallurgy, Harvard University
612 pages 6¾ x 9¾, cloth, $5.00.

PYRITE SMELTING
By T. A. RICKARD
210 pages 6¾ x 9¾, $2.00.

THE METALLURGY OF LEAD
By H. O. HOFMAN
Professor of Metallurgy, Massachusetts Institute of Technology
600 pages 6¾ x 9¾, $6.00.

HYDROMETALLURGY OF SILVER
By OTTOKAR HOFMANN
336 pages 6¾ x 9¾, cloth, $4.00.

MANUFACTURE AND PROPERTIES OF IRON AND STEEL
HARRY HUSE CAMPBELL
640 pages, 6 x 9, illustrated, $5.00.

METALLURGICAL CALCULATIONS
PART I. CHEMICAL PRINCIPLES
By PROF. JOSEPH W. RICHARDS
200 pages, cloth, $2.00 net.

METALLURGICAL CALCULATIONS
PART II. IRON AND STEEL
By PROF. JOSEPH W. RICHARDS
250 pages, cloth, $2.00 net.

IRON, STEEL AND OTHER ALLOYS
By PROF. HENRY M. HOWE
Second edition, 513 pages, 123 illustrations. Price $5.00 net.

METALLURGICAL LABORATORY NOTES
By PROF. HENRY M. HOWE
154 pages, 44 illustrations. Price, $2.50 net.

In this book the author describes ninety-one laboratory experiments conducted by students in the Department of Metallurgy of the School of Mines of Columbia University, and deals with Pyrometry, Calorimetry, Metallography, Heat Treatment of Steel, etc.

ELECTROMETALLURGY

ELECTRIC SMELTING AND REFINING
By DR. W. BORCHERS. Translated by W. G. McMILLAN.
Second edition, 562 pages, 255 illustrations. Price, $7.00.

This book treats of all those metals in the extraction and working of which the electric current has found any application. A survey of the purely metallurgical methods of treatment has been added to each chapter, so the two methods may be readily compared.

THE ELECTRIC FURNACE
By HENRI MOISSAN
Authorized Translation By DR. VICTOR LENHER
305 pages, illustrated. Price, $2.50.

A complete description of this recent apparatus and its application to the fusion and volatilization of refractory substances. The work is brought up to date by accounts of recent development.

Any of the above books sent postpaid on receipt of price.

We can promptly furnish any Metallurgical, Chemical or Engineering book.

ELECTROCHEMICAL PUB. CO.
Book Dept. **114 Liberty St, New York**

distinguishes them from a well designed ordinary stationary transformer: the large magnetic leakage. To the future theorists of the electric induction furnace Dr. McAllister's book is heartily recommended.

An Investigation of the Borides and the Silicides. By Oliver Patterson Watts, Ph. D. 68 pages; illustrated. Price 30 cents. Madison, Wis.: Bulletin of the University of Wisconsin No. 145.

This is an excellent little monograph on the electrometallurgy of the borides and the silicides, and reflects high credit on the institution from which it has been issued—the laboratory of applied electrochemistry of the University of Wisconsin, which is in charge of Prof. C. F. Burgess.

In the first part of the pamphlet a very useful summary is given of the existing literature on silicides and borides. Most of the work in these fields in the past has been done in France and in Germany. The results of the work of the different experimenters are worked up by Dr. Watts in form of various tables giving the references to original articles, an indication of the method of preparation of the different compounds and notes on their physical and chemical properties. The lists include 23 borides and 36 silicides. It appears that the usual method of preparing these compounds has been that of direct synthesis from the elements; occasionally the metallic oxide has been reduced by boron or silicon, and still more rarely the oxygen compounds of both the metal and the non-metal have been simultaneously reduced by carbon or magnesium.

The second part of the bulletin is an account of the author's own experimental work, which was undertaken for two purposes. The first was to investigate the possibility of preparing the borides and silicides from their commercial available oxygen compounds by a single reaction in the electric furnace; the second was to attempt to produce a new series of definite chemical compounds—the silico-borides.

Dr. Watts first gives an interesting brief summary of the various reducing agents which are available for the electric furnace. Carbon is, of course, the most important metallurgical reducing agent, and for the electric furnaces it has certain advantages. It is cheap, it is a powerful reducing agent at high temperatures, it is so slightly volatile that it remains in the furnace while the product of its action is a gas and hence escapes as soon as formed. The great disadvantage of carbon is its tendency to form carbides with nearly all metals which are produced in the electric furnace, and also in the presence of silica or borax, to form the carbides of silicon and boron, extremely resistant to chemical reagents and difficult to remove from the product desired. In the reduction of the metallic oxides the amount of carbon in the product may be made very small, and even negligible in some cases, by using an excess of metallic oxide in the charge. In the preparation of borides and silicides from their oxygen compounds, however, this method of removal of carbon from the product is not available.

Aluminium has been found an excellent reducing agent mainly as the result of Dr. Hans Goldschmidt's extensive work in this field. Dr. Watts has tried a modification of the Goldschmidt aluminothermic method. The main feature of the latter is, of course, that no outside supply of power is required. Dr. Watts has found that for certain reactions it is useful to combine the aluminothermic method with an electric furnace treatment, and has developed a method of firing in the electric furnace a charge consisting of powdered aluminium and any other powdered substance or substances that he desired to reduce, and obtained a product free from both carbon and aluminium. Besides applying the method to rutile, boric and tungstic "acids" were similarly reduced, and by the addition of a retarder to check the vigor of reaction, ordinary Goldschmidt charges were fired in the electric furnace without accident. (See also our Vol. III., p. 372.)

Another useful reducing agent is calcium carbide, which reduces the same classes of compounds as are reduced by

aluminium, and is especially advantageous to use for mixtures of an oxide with a chloride or a sulphide. It seems to be settled that calcium alloys are produced in certain reductions, but the exact conditions which cause their formation are not yet established. The products are contammated by carbon under the same conditions, and possibly to the same extent, as if free carbon were used for reduction.

After giving a few notes on the use of aluminium carbide and silicon carbide as reducing agent, the author speaks of calcium which is now made commercially on a large scale and which is believed by Dr. Watts to be superior to any other general reducing agent, where purity of the product of reduction is of importance. "The metal in granular or powdered form can undoubtedly be used as aluminium now is in the Goldschmidt method of reduction. For this use it will be superior to aluminium for different reductions. For one equivalent of oxygen its heat of oxidation is 10 per cent greater than that of aluminium—a sufficient increase to insure the completion of certain reductions that by aluminium are only partial. Mixtures of oxides with calcium will undoubtedly have a considerably lower kindling point than those with aluminium, a quality which will be a convenience, and will tend to cause more rapid and complete reaction. A disadvantage of calcium as compared with aluminium is its oxidation at ordinary temperatures. Another, and possibly serious objection to calcium as a reducing agent in the electric furnace is to be seen in the strong oxidizing action of fused lime upon silicon, boron, chromium, cobalt, iron, manganese, nickel and titanium in the experiments of Moissan."

A few words are then said on the important subject of slags and the general arrangement of the author's experiments is described. In the first experiments he endeavored to make silicides from sulphide ores. For instance, silicon copper from chalcocite, Cu_2S, and silica in one reaction, or ferro-silicon from ferrous sulphite and silica. The equation of the reduction of silicon copper from Cu_2S with calcium carbide as reducing agent is, for instance, $Cu_2S + SiO_2 + CaC_2 = Cu_2Si + CaS + 2CO$. The general results of this series of experiments are that metallic sulphides and silicates can be simultaneously reduced by calcium carbide or aluminium with the production of a silicon alloy. The total yield, based on both the metal and non-metal in the charge, is little above 50 per cent. The use of carbon or a carbide as reducing agent introduces carbon into the metallic silicides of those metals capable of uniting with carbon. The product can be obtained entirely free from sulphur by the use of lime or aluminium. In the course of these experiments the author found a new silicide of molybdenum which is richer in silicon than Mo_2Si_3, and probably has the formula of $MoSi_2$. The author's attempt to use an analogous method for preparing the borides was unsuccessful as was also his attempt to find a series of silico-borides, although his experiments do not prove that such a series does not exist.

The Bulletin is concluded by some interesting notes on the behavior of the horizontal arc furnace in which the experiments were carried out. The resistance of the arc depends upon four factors. First, on the length of the arc. Second, on the current strength; an increase of current increases the cross-section of the arc, and therefore diminishes the resistance. Thirdly, the resistance of the arc depends on the temperature of the furnace. During the rise in temperature at the beginning of an experiment the arc must be gradually lengthened if the current is to be maintained constant. When a cold charge is fed into a hot furnace the current is diminished. Fourthly, the quantity and nature of vapors within the furnace are also a factor of influence on the resistance of the arc. An increase in the amount of vapors of sodium and of silicon lowers the resistance. Possibly there are vapors which are capable of increasing the resistance. From various data the author concludes that the arc tends to maintain a constant ratio between its own resistance and that of the remainder of

Dreaper

The Chemistry and Physics of Dyeing

Being an Account of the Relations between Fibres and Dyes, the Formation of Lakes, and the General Reactions of Colloids, and their Solution State.

By W. P. DREAPER, F.I.C., F.C.S.

Illustrated by Curves and Numerous Tabulated Results

Octavo. *Cloth, net $3.00*

In the present volume an attempt is made to collect and classify the work which has been brought forward to explain the action of dyeing, mordanting and lake formation. The general text books on dyeing devote little space to this particular side of the question. They deal with the operations of the dye-house, rather than with the principles which seem to govern the actual practice of this branch of the industry. It is advisable that the modern dyer should have some knowledge of the general reactions which give rise to the results obtained in the many processes involved in the dyeing and bleaching of textile fibres. Without some such knowledge it is difficult to appreciate their nature, or be in a position to control their working in a systematic manner.

Catalog of Chemical Books sent free upon request

P. Blakiston's Son & Co.

Publishers

1012 Walnut Street, Philadelphia

Handbook of Mathematics

FOR ENGINEERS AND ENGINEERING STUDENTS

By J. CLAUDEL

Translated and Edited from the Seventh French Edition by OTIS ALLEN KENYON

A complete book on Mathematics
It covers very thoroughly
Every branch from Arithmetic to Calculus

TABLE OF CONTENTS

PART I.—ARITHMETIC. I.—Fundamental Operations on Whole Numbers. II.—Properties of Whole Divisors. III.—Fractions and Decimal Numbers. IV.—Powers and Roots. V.—Ratios, Proportions, Progressions. VI.—Diverse Rules. VII.—Logarithms. PART II.—ALGEBRA. I.—Of the Four Fundamental Algebraic Operations. II.—Equations of the First Degree. III.—Powers and Roots of the Algebraic Quantities. IV.—Equations of the Second Degree. PART III.—GEOMETRY. Plane Geometry. Solid Geometry. Problems in Geometry. PART IV.—TRIGONOMETRY.—Plane. Spherical Trigonometry. PART V.—ANALYTICAL GEOMETRY. PART VI.—CALCULUS. I.—Differential Calculus. II.—Integral Calculus. III.—Applications of Integral Calculus.

Cloth, 708 Pages. 422 Illustrations. Price, $3.50 Net.
Sent anywhere postpaid for the price
Send Us Your Inquiries Write For Our Catalogs

McGraw Publishing Company

PUBLISHERS, IMPORTERS AND BOOKSELLERS

114 Liberty Street, New York

DUHEM-BURGESS—*Thermodynamics and Chemistry.* A Non-Mathematical Treatise for Chemists and Students of Chemistry. By P. Duhem. Correspondant de l'Institut de France; Professor of Theoretical Physics at the University of Bordeaux. Authorized Translation by George K. Burgess, Docteur de l'Université de Paris; 8vo, xxi+445 pages, 140 figures. Cloth, $4.00.

GETMAN—*Laboratory Exercises in Physical Chemistry.* By Frederick H. Getman, Ph. D., Fellow by Courtesy of The Johns Hopkins University, Carnegie Research Assistant. 12mo, viii+241 pages, 100 figures. Cloth, $2.00 net.

LÖB-LORENZ—*Electrochemistry of Organic Compounds.* By Dr. Walther Lob, Privatdocent in the University of Bonn. Authorized Translation by H. W. F. Lorenz, A.M., Ph.D., 8vo, x+308 pages, 10 figures. Cloth, $3.00.

WEAVER—*Notes on Military Explosives.* By Erasmus M. Weaver, Lt. Col. Artillery Corps, U. S. Army. 8vo, viii+311 pages. Cloth, $3.00 net.

JOHN WILEY & SONS
43 & 45 E. 19th St., New York City

Eleventh Edition

Metallurgy of Cast Iron

A complete exposition of the processes involved in its treatment, chemically and physically, from the blast furnace through the foundry to the testing machine, being a practical compilation of original research.

By THOMAS D. WEST

Contents

PART I.—Manufacture and Use of Coke—Properties in Ores—Operations of Blast Furnaces—The Different Brands of Pig-Iron and How to Purchase and Use Them Intelligently (27 chapters). II.—Elements in Cast-Iron and Their Physical Effect—Utility of Chemical Analyses and How to Use Them in Making the Different Mixtures of Irons Used in Making Gray and Chilled Castings (21 chapters). III.—Properties of and Methods for Testing Molten Iron—Phenomena in the Actions of Cooling Metal, etc.—Results of Tests in All Kinds of Irons—Best Methods for Testing (23 chapters). APPENDIX. Selected Tables for Use in Furnace and Foundry Work.

Cloth 638 Pages 153 Illustrations Price, $3.00 net

Sent Anywhere, postpaid, for the Price by the

McGRAW PUBLISHING COMPANY

114 Liberty Street :: New York

the circuit, or an arc of fixed length tends to maintain a constant voltage.

When trouble is experienced with the arc, on account of its being unsteady, the source of trouble is found at the anode, and seems to Dr. Watts to be due to insufficient heat to maintain there a layer of carbon vapor.

Electrode losses are due to three causes, according to Dr. Watts; first, volatilization from the crater, confined to the anode; second, oxidation; and, third, disintegration—particles falling from the electrodes. The first cause is independent of, the second and third are dependent upon, the length of electrode within the furnace. The total loss is diminished about 50 per cent by filling the furnace with illuminating gas; this can diminish only the second and third effects. The losses with 2-inch electrodes were double those with 1½-inch diameter. This points to the use of the smallest possible electrodes. In the whole it will be seen that the little booklet contains much useful information.

* * *

Über Ferrosilicium. By Dr.-Ing. Waldemar Pick. 97 pages; illustrated. Printed by G. Braun in Karlsruhe.

We are obliged to the author for sending us this very interesting book, which apparently has no regular publisher and cannot be obtained through the ordinary channels for buying books. But we are glad to learn that Dr. Pick has in preparation—jointly with Dr. W. Conrad—an enlarged and revised edition of this work which shall be placed on the book market. For these reasons the following notes are brief, and a full review such as the subject deserves on account of its timeliness and importance shall be deferred.

This is the first book on ferro-silicon and is based on the author's "experience, investigations and experiments during several years of practical activity in electrochemical works, and especially in the ferro-silicon industry." In the first part of the book a general discussion of the properties, etc., of the iron-silicon alloys and of the definite ferro-silicides is given. There is an interesting discussion of the reasons which may underlie the gradual disintegration in the atmosphere of ferro-silicon containing between 30 and 65 per cent Si, and of the cognate subject of the occasional occurrence of ferro-silicon explosions. After a few brief notes on the production of ferro-silicon in the blast furnace, historical notes are given on the use of the electric furnace for ferro-silicon manufacture. The principal patents relating to the subject are summed up. Chalmot's patents are very well spoken of by the author.

What he then says of the methods of making ferro-silicon on an industrial scale, on the equipment of the works and the construction of the furnaces (especially of the Rathenau type) is very interesting. But since we understand that this chapter is to be considerably extended in the next edition we will not review it now.

Dr. Pick then gives the thermochemical theory of the process upon which he bases an analysis of the results obtained in actual practice. The various factors which influence the efficiency of the process are discussed and the effect of the composition of the raw materials on the purity of the product is given. He considers as reliable the figure of Keller, according to whom in the production of 30 per cent ferro-silicon 1 kw.-day yields 6.66 kilograms of this product, corresponding to 2 kg. of silicon. From the cost sheets given by the author one point is evident to which we have repeatedly called attention: that is the importance of the cost of electrical energy on the resulting cost of ferro-silicon. Thus in his estimate for a 3,000-hp. plant in upper Silesia, producing 13 tons of 30 per cent of ferro-silicon per day, the total cost per ton is estimated as $41.00; the largest item in the cost sheet is the electrical energy, amounting to not less than $18.00, although the cost of the kilowatt-hour is assumed here at as low a figure as 0.5 cent. The new edition of the book will certainly be awaited with interest.

Electrochemical and Metallurgical Industry

Vol. V. New York, September, 1907. No. 9.

Electrochemical and Metallurgical Industry

With which is Incorporated Iron and Steel Magazine

Published on the first of each month by the
ELECTROCHEMICAL PUBLISHING COMPANY,
[*Incorporated.*]
239 WEST THIRTY NINTH STREET, NEW YORK.

J. W. Richards, Ph. D. ..... *President*
E. F. Roeber, Ph. D. ..... *Editor and Secretary*
C. E. Whittlesey ..... *Treasurer*

Subscription Price: $2 per year, postpaid to any part of the world. Single copies 25 cents.

Copyrighted, 1907, by the Electrochemical Publishing Co.

Entered as Second-Class Matter, June, 1903, at the Post-Office at New York, N. Y., under the Act of Congress, March 3, 1879.

New York, September, 1907.

CONTENTS.

Editorial 341
Announcement 341
Prices of Metals in the Fall 341
Combustion and Dissociation 342
Fixation of Atmospheric Nitrogen 342
Again the Corrosion of Iron 343
The Iron and Steel Market 344
A New Steel Process 344
The Detinning Suit 345
Correspondence:
Detinning with Chlorine. By C. Offerhaus 346
A New Iron-Carbon Phase, Osmondite. By Henry M. Howe 347
Rapid and Accurate Gas Analysis. By Edwin Barnhart 350
Metallurgical Calculations (copper). By J. W. Richards 352
Electrothermic Combustion of Atmospheric Nitrogen. By F. Howles 358
Use of Producer Gas in the Chemical Industries. By Oskar Nagel 360
Fixation of Nitrogen. By M. Whitehouse 361
Corrosion of Iron. Two papers by W. H. Walker, A. M. Colebrolm and L. N. Bent, and by A. S. Cushman 363
The Heat Content of Iron. By J. W. Richards 366
The Electrothermic Reduction of Iron Ores. By Albert E. Greene and Frank S. MacGregor 367
Transmutation of Elements. By Sir William Ramsay 371
Notes on Electrochemistry and Metallurgy in Great Britain 371
Synopsis of Periodical Literature 375
Analysis of Current Electrochemical Patents 377
Recent Metallurgical Patents 379
Speed Recorder 380
New York Meeting of the American Electrochemical Society 381
Iron and Steel Institute Meeting 381
Notes 381
Obituary (Sir William Perkins) 382
Digest of United States Patents. (Calcium Carbide) 382
New Books 383
Book Reviews:
A. Hollard and L. Bertaux on Metallanalyse auf Elektrochemischem Wege 384
Walter Harvey Weed on the Metal Mines of the World 384
C. F. Emmons and E. C. Eckels' Contributions to Economic Geology, 1906 384
E. F. Burkhardt on Gypsum 385
Max Orthey's Laboratoriumsbuch für den Eisenhütten Chemiker 385
Transactions of the Faraday Society. Vol. III., Part I 385
W. M. Carr on Open-Hearth Steel Castings 386

Announcement.

After Sept. 1 the offices of this journal will be removed to the new "Thirty-ninth Street Building," 239 West Thirty-ninth Street. This location is in the heart of what is predestined to become a most important business center of New York City after the completion of the various tunnels and the new Pennsylvania Railroad station. Our friends will enjoy being able to reach us in a three minutes' walk from the United Engineering Building or the Engineers' Club, or in some fifteen minutes from the Chemists' Club. The building itself is interesting from an engineering standpoint as the most important reinforced concrete office building on Manhattan Island.

◆◆◆

Prices of the Metals in the Fall.

As we predicted last winter, the price of copper has taken a tumble; 25-cent copper was altogether too high, and nothing warranted the continuation for a long time of the price of metals at such figures. It was restricting consumption. As nobody will buy in a falling market, the copper market exhibits a most plastic condition. It has been "punched" hard by the offering of the smaller mining and smelting companies who have a fat margin at present prices, and also by the large custom smelters who have to sell the copper from a number of small producers of ore. It is doubtful if the larger companies who are trying to hold up the price can continue to accumulate stocks of metal. It should be remembered that they had an unfortunate experience in 1901, when the same thing was attempted. It should also be remembered that present prices are even higher than in 1901, when the big producer tried to hold the umbrella over the market.

* * *

Pig iron and steel products are selling on old orders, but there also appears the same deadlock between producer and consumer. The wise policy of the dominating interest in holding down prices in 1906-7 below prices of 1902 prevented a runaway market. Lead, of course, is sold on quotations made by the "trust," and its price is largely artificial, especially as same interests are largely interested in the consuming companies. The spelter market has been distressingly weak, and spelter soon will be selling at prices where neither mine owner nor smelter can make a dollar. The free competition in this field, however, has caused the drop to such a price, that cost of production fixes the price of metal rather than monopolistic control. It is probable that the reaction has been a good thing for business, for high prices surely throttle consumption. When prices react and people recover from the hysteria that a falling market always engenders, we see no reason for fear that political disturbances of the presidential year will do any more than slow down business to a normal basis.

Combustion and Dissociation.

It was a favorite mode of expression—and is still commonly used—to say that the temperatures attained by ordinary combustion are limited because of the dissociation of the products of combustion as high temperatures are reached. We opine that most books on combustion, even at the present moment, are continuing to spread this erroneous view. The facts are, that if CO_2 and H_2O do dissociate to anything like the extent which St. Claire Deville and other early experimenters on dissociation believed, then our furnace temperatures are seriously kept down by that dissociation. But that idea has been repeatedly shown to be false, yet it dies hard. Water vapor and CO_2 dissociate to such an inappreciable extent at all ordinary furnace temperatures that the effect on the resulting temperature is in reality negligible. Langmuir published in the last volume of the *Journal* of the American Chemical Society (XXVIII., 1,358-1,379) a very laborious determination of the dissociation of H_2O vapor and CO_2, finding them to be, at 1,000° C., dissociated to the extents of 0.003 per cent and 0.004 per cent respectively; at 1,500° C. to 0.17 and 0.55 per cent, and even at 2,000° C. to the extent of only 1.3 and 5 per cent. It follows, that wherever a fuel containing carbon and hydrogen is burned, the dissociation of the products by their own self-generated high temperature does not check that temperature more than 0.05° C. at 1,000°, or 9° C., at 1,500° C., or 50° to 100° at 2,000°. Since our open-hearth furnace roofs commence to melt at 1,750°, we are not in practice suffering at all from low temperatures produced by supposed dissociation of H_2O and CO_2. Let us revise our modes of speech and talk according to present known facts.

Fixation of Atmospheric Nitrogen.

In our April issue, 1900, we referred to a certain scheme of producing ammonia from nitrogen of the air, on the basis of the property of certain elements to combine comparatively easily with nitrogen. Thus lithium forms a nitride according to the equation $3Li + N = Li_3N$. By treating the nitride with water it is then possible to get ammonia with the simultaneous formation of lithium hydroxide. The lithium is, of course, intended to be employed simply as a carrier for the nitrogen, and is to be used over and over again. To make the process cyclic, with respect to lithium, it becomes necessary to regenerate the lithium from the hydroxide. This could be done by electrolysis. But the whole process is undoubtedly too complicated and expensive to be attractive. In our present issue we publish a paper by Mr. Norman Whitehouse on an interesting research carried out at the suggestion of Sir William Ramsay. The intention was to try a scheme quite similar to that sketched above, but greatly simplified in so far as the nitride formed is not treated with water, but with hydrogen or water gas to produce directly ammonia and regenerate the metal.

* * *

If practicable such a process would be delightfully simple. If we designate with M the metal which is to act as nitrogen-carrier, the two steps of the process would be $M + N = MN$ and $MN + 3H = M + NH_3$, and so on. Unfortunately, Mr. Whitehouse's experiments seem to prove conclusively—and this is the valuable result of his paper—that those elements which he tried do not behave like our hypothetical metal M. The trouble is that with real metals we may be able to produce either the first or the second reaction, but not both together. Metallic nitrides may be directly reducible to form ammonia, but such nitrides cannot be directly produced from the elements. Other nitrides may be made directly from the elements, but are not directly reducible. Thus, although very attractive, this scheme seems not capable of realization, and we are thrown back on electrical methods for the fixation of atmospheric nitrogen.

* * *

The paper of Mr. F. Howles, of which we publish a long abstract in this issue, gives an interesting résumé of the chief processes employing electric discharges through air. Mr. Howles, who has been himself an early worker in this field, shows clearly the points in which the early experimenters failed. Mr. Howles is on the solid ground of the physico-chemical theory that the effect of the arc or spark discharge is simply thermal. We have to do with an electric furnace process. We thus have the two well-known requirements that we need as high a temperature as possible in the active zone of the arc, and that we must remove the gas mixture from the sphere of influence of the arc so quickly as to prevent dissociation in the cooler parts of the arc. But Mr. Howles adds another important consideration for a commercial process, namely, that it is necessary to concentrate as large an amount of energy in a unit of plant as possible to keep maintenance and labor charges down. It was in this point that the early processes failed. This is very important, since we have two main expenses which cannot be avoided, one is the expense for the electrical energy, the other the expense for working up the end product of the electric furnace process—a mixture of gases containing somewhat like 2 per cent of nitric acid into a marketable product.

* * *

Because the Birkeland-Eyde process is commercially successful in Norway, we like to speak of the problem as solved, which is correct to a certain extent. But it is significant that the process does not appear to make much headway elsewhere. The fact is that the very cheap power in Norway (somewhat like $5 per horsepower-year) represents a very special condition. These Norwegian conditions cannot be duplicated in this country, and if we could get power so cheaply it would probably pay better in most localities to utilize it for other purposes. However, it would seem that the process has not yet reached finality, and we may expect that the persistent and indefatigable work of the Norwegian pioneers will succeed in further reducing the cost of the process. In the meanwhile the other process of fixing atmospheric nitrogen—the manufacture of calcium cyanamide—is gradually extending from the pioneer plant in Italy into other countries. Thus, in this country a plant is planned for the South. The two chief items of the cost are here the raw materials: the calcium carbide and the nitrogen, which must first be separated from the oxygen in the air. The calcium cyanamide manufacture itself is simple. We have not heard of the special method which will be used in the Southern plant to separate the nitrogen from the oxygen in the air. In the Italian plant distillation of liquid air is reported to be employed. It is perhaps significant that the manufacture of liquid air apparatus is just now entering into the commercial stage in this country.

Again the Corrosion of Iron.

The two papers of Dr. Walker and Dr. Cushman, published elsewhere in this issue, give us an opportunity to add some further comment to our remarks in the July issue. We have now three important hypotheses on the causes of corrosion of iron. The carbon dioxide theory, originally proposed by Grace Calvert and Crum Brown, and now strongly defended by Mr. Moody, assumes that the corrosion of iron proceeds in two steps, the first of which assumes the presence of carbon dioxide. The equations of the two reactions are: (1) $Fe + H_2O + CO_2 = FeCO_3 + H_2$ and (2) $4FeCO_3 + 6H_2O + O_2 = 2Fe_2O_3(H_2O)_3 + 4CO_2$. Hence, in the second step carbon dioxide is reformed, which then acts on fresh iron, and so on. The hydrogen peroxide theory also assumes that the corrosion of iron proceeds in two steps, of which the first is the formation of hydrogen peroxide by the reaction (3) $Fe + O_2 + H_2O = FeO + H_2O_2$, while the second step is the action of H_2O_2 on Fe and FeO, according to the equations (4^a) $Fe + H_2O_2 = FeO + H_2O$ and (4^b) $2FeO + H_2O_2 = Fe_2O_3(H_2O)$. The electrolytic theory, originally proposed by Dr. W. R. Whitney and now so ably defended and further developed by Dr. Cushman and Dr. Walker, assumes that when an iron surface is in contact with moisture, which may act as an electrolyte, differences in the composition of the iron will result in making some parts of the iron surface anodes and other parts cathodes. Thus, we have short-circuited galvanic cells. At the anode the iron will pass into solution, assuming the ferrous ionic state, while hydrogen is liberated at the cathode, the equation being most easily expressed in the notation of the ionic theory (5) $Fe + 2H^{+} = Fe^{++} + H_2$. For those who object to the electrolytic dissociation theory, this equation will mean nothing more than that one free iron atom gains two bonds, while simultaneously two monovalent hydrogen ions lose each one bond; expressed in this way the equation cannot be objectionable to anybody. The second step is the oxidation of the ferrous ions to ferric by oxygen of the air. The equation may tentatively be written (for argument's sake, although it is not the most general form) (6) $2Fe.A + (x + 2)H_2O + O = Fe_2O_3(H_2O)_x + 2H_2A$, where A stands for any bivalent anion. Here the two bivalent Fe atoms on the left hand gain each one positive bond and become trivalent, while the one free O ion on the left-hand gains two negative bonds. The loose colloidal ferric hydroxide moves towards the cathode under the influence of the current and piles up there in form of rust.

* * *

It is unnecessary to emphasize the differences between the three theories. It seems more useful to point out how far they agree. All three theories agree that the oxidation of iron by oxygen of the air is not direct, and in this point they agree clearly with all experimentally established facts. Further, all three theories agree that the formation of rust proceeds in essentially two steps, of which the first step is the passing of the free metallic iron into the bivalent state, and that the formation of rust is a subsequent second step, involving the change from the ferrous to the ferric state. According to the carbon dioxide theory, the first step is the change of Fe to $FeCO_3$, a bivalent compound; according to the hydrogen peroxide theory the change is from Fe to FeO, also a bivalent compound; while the electrolytic theory simply claims the metallic iron to pass into solution and get bivalent. Evidently the electrolytic theory which leaves the question of the anion entirely open is the more general theory, and in this respect it comprises the other two theories as special cases, representing possible, but not necessary, reactions. The adherents of the electrolytic theory cannot deny that when iron is in contact with carbon dioxide, water and oxygen, the reactions claimed by the carbon dioxide theory will occur; but they deny that it is by means of these special reactions that rust is formed in general, and Dr. Cushman's and Dr. Walker's repetition of Mr. Moody's experiments appear to offer conclusive evidence in favor of their theory. Viewed from the standpoint of the electrolytic theory, the carbon dioxide theory emphasizes one single possible anodic reaction, namely, the change of iron into ferrous carbonate. On the other hand, the hydrogen peroxide theory seems to emphasize to a certain extent one single possible cathodic reaction, if we follow the interesting suggestion of Dr. Walker. It was found by Richarz and Lonnes that the electrolysis of water saturated with air is possible at a relatively low electromotive force, because the air in the water acts as a depolarizer at the cathode, so that the cathodic product is not hydrogen gas but hydrogen peroxide. If hydrogen peroxide can exist at an iron surface, we should expect it to be formed at such spots of the iron which act as cathodes, and this formation (on account of the lower potential compared with hydrogen gas development) would accelerate the passing of iron from the anodic areas into the ferrous ionic state.

* * *

While the subject is of highest theoretical interest, it is of no less practical importance. What can be done to overcome the innumerable troubles due to corrosion of iron? Surely Dr. Cushman's suggestion to try treatment with bichromate solutions on a large scale deserves fullest attention. It should be noticed that Dr. Cushman is exceedingly careful and conservative in his predictions, yet he concludes: "Although it is true that laboratory tests are frequently unsuccessful in imitating the conditions in service, it, nevertheless, appears that chromic acid and its salts should under certain circumstances come into use to inhibit extremely rapid corrosion by electrolysis." However, we should not overlook that such treatment is somewhat like treating a sick person continually with medicines and nursing him along in such a way without restoring him really to health. The fundamental trouble in the corrosion of iron lies in the iron itself, in its non-uniformity. Treatment with chromic acid has only a temporary superficial effect and does not change the composition of the iron. The radical cure to prevent corrosion of steel would be to make better steel, "as free as possible from certain impurities such as manganese, and so homogeneous as not to retain localized positive and negative nodes for a long time without change." This is quoted from Dr. Cushman, with whom we fully agree, but we may add again what we already pointed out in the July issue, that according to the present state of art it is quite possible that the cheapest way to do this might be to treat open-hearth or Bessemer steel subsequently in the electric furnace. If the corrosion of iron is an electrolytic process and electrochemistry is at the bottom of the corrosion trouble, it would be only proper that another branch of electrochemistry—the electric furnace—should solve the problem.

The Iron and Steel Market.

The situation in the market in July has been carried over from August. There has been substantially no buying of any kind worth mentioning. On finished material there has been very little in the way of entering into absolutely new engagements, there has been a fair but only fair, run of specifications and orders against old contracts.

The market exhibited a new phenomenon; through this extreme dullness production has kept up to the physical limits. Never before has such a period of market dullness failed to make an impress upon actual production, and the present situation is a testimony to the soundness of the contract obligations which the furnaces and mills had on their books at the end of the second quarter.

It is true production has declined slightly, but this was due entirely to the hot summer weather. Pig iron production has declined slightly, but less than it usually does in mid-summer, as several new furnaces have been blown in. Practically all the pig iron has gone into consumption, and the steel in turn has been rolled into finished forms and shipped. The accumulations of foundry pig iron at furnaces and in consumers' yards has been very slight.

It is a question now whether or not a genuine fresh buying movement will be inaugurated in time to save the situation or, failing this, how long the present obligations will permit of full activity. The prospects of a heavy buying movement are far from favorable. It is found that money is really tight, and there is no good reason to believe that the much-heralded retrenchment policy of the railroads will be abandoned. It certainly looks as if general business would have to be conducted on a somewhat reduced plane, as to both prices and volume. The financial world seems to have been going on the basis for several years that the increase in the gold production meant an equal increase in the amount of gold available as money; now that conditions require a more careful scrutiny it is developed that the supply of money has not increased half as much as has the production of gold, a fact which men could have discovered before had they taken pains. As to the railroads' retrenchment policy, the Southern Railway has reduced its preferred dividend, making a statement that the reduction is due to higher costs, and Wall Street judges that some other roads will have to make dividend reductions. These things do not augur for liberal expenditures for iron and steel products on the part of the railroads.

Events have shown the justice of our remarks a month ago on the strength of Lake Superior ore docks and mines. The strike ended after a total loss in shipments of 2,000,000 or 3,000,000 tons at the outside, and it is now certain that all the ore which will be needed can still be brought down.

Pig Iron.

There has been no buying except of occasional small lots for early shipment. Prices on such transactions have been from 50 cents to a dollar lower than the market two months ago for deliveries late in the year. For such late delivery there is now no market at all, so that similar deliveries cannot be compared. The United States Steel Corporation bought 15,000 tons of Bessemer for August delivery, paying $22, valley furnace, equal to $22.90, delivered Pittsburg, or 50 cents less than had previously been done on any delivery. It is extremely unlikely that it will buy any September iron, as it will not need it, and would not want to support the market, as it would prefer to see lower prices on Bessemer pig. The Cambria Steel Co., which has been getting about 10,000 tons a month from the open market, has blown in its new No. 8 furnace, and will not require outside iron after Sept. 1. This will release 25,000 tons or more of Bessemer pig on the market, and lower prices appear inevitable. In basic pig it has been impossible to move the iron which has been offered for some time, and with the blowing in of the Inland Steel Co.'s new furnace the iron it has been taking will also have to be disposed of. Basic has been nominally $21, valley, but there is no question that this price could be shaded.

In foundry pig iron a condition of extreme apathy prevails. Deliveries are pretty well taken but there is no interest whatever in future deliveries. Prices are purely nominal, as there is nothing to test the market. Nominally No. 2 foundry can be quoted at $22, valley furnace, or $22.90, Pittsburg, and forge $1 to $1.50 less.

Steel.

The purchases of billets by the United States Steel Corporation, made through its subsidiary, the Carnegie Steel Co., are being continued at intervals. During the second quarter 50,000 tons were bought, and during July 30,500 tons, while in August a smaller quantity was taken. Prices are fairly well maintained considering the lack of interest. Bessemer billets can be had at $29, maker's mill, or perhaps a trifle less, and open-hearth billets at about $30, maker's mill. A number of mills are not sellers at all.

Finished Material.

Nothing new has been developed in the situation as to specifications for rails for 1908 delivery. The committee will meet some time in September. The mills are well filled up for the current year.

Throughout the finished steel trade mills are well filled with specifications and can run at full capacity for some time yet. In sheets there is some strictly new business, while orders and specifications on old contracts are excellent. In steel bars conditions are about the same as in sheets. In plates and shapes there is very little absolutely new business, but fairly good specifications. Prices are unchanged, except that iron bars are slightly easier, and are quotably lower for Pittsburg delivery. Prices are as follows, f. o. b. Pittsburg.

Structural shapes, $1.70 per 100 pounds for beams and channels, 15 inches and under.

Plates, $1.70 for tank quality.

Merchant steel bars, $1.60, base.

Common iron bars, $1.70, delivered Pittsburg, and $1.60, f. o. b. Pittsburg, for Western delivery.

Sheets, 28 gauge $2.60 for black and $3.75 for galvanized.

Tin plates, $3.90 for 100-pound cokes.

A New Steel Process.

In our July issue, page 270, and in our August issue, page 322, we have already noticed two patents granted to Mr. Horace W. Lash for a new electric steel process, and in the Analysis of Current Electrochemical Patents in our present issue an abstract will be found of a third patent granted to Mr. Lash.

Mr. Lash is the vice-president of the Garrett-Cromwell Engineering Co., of Cleveland, and for the introduction of his steel process into practical use the Lash Steel Process Co., of Cleveland, Ohio, and the Canadian Lash Steel Process Co., Ltd., of Toronto, Ont., have been formed. The general offices of both companies are in the White Building, Buffalo, N. Y., Mr. Seward Babbitt (formerly with the De La Vergne Machine Co.) being secretary and general manager.

The chief claim made for the process is that it produces steel of good open-hearth quality from a mixture of iron oxide and pig or cast iron. The quantity of cast iron required never needs to be more than that of the iron oxide and may be considerably less, successful results having been obtained when the cast iron was not more than one-fourth of the weight of the iron oxide.

The iron oxide and the pig iron must be used in a finely

divided condition. Hence if iron ore is used it must first be crushed. The process is, however, well adapted to the direct treatment of magnetic concentrates, such as produced from the sand ores of the St. Lawrence and New Zealand or on the Pacific Coast, or from the magnetic ore mines in Northern New York and Canada. It is important to note that association of such substances as titanium oxide does not interfere with the process.

The process, therefore, appears to offer a solution of the problem which has been attacked so often in the past—the reduction of magnetic concentrates. It is interesting to compare this process with another electric process which was devised for the same purpose, that of Mr. Ruthenburg. In the Ruthenburg process the electric furnace simply serves for fritting the concentrates together into lumps, the reduction to be carried out afterwards while the lumps are hot but not molten. In Mr. Lash's process the reduction goes on while the charge is actually molten.

It has already been noted that the pig or cast iron must also be in a finely divided or shotted condition. But it is to be emphasized that it must be that quality of iron commonly designated as cast or pig iron, as distinguished from the ordinary run of scrap, wrought iron or steel, since it is important that it contains a high percentage of metalloids or oxidizable metals such as manganese, capable of uniting with the oxygen of the ore. Besides iron oxide and cast iron the charge contains carbon as reducing agent, preferably in form of ordinary coke and finely ground, also fluxes of the ordinary kind, such as lime, silica or fluorspar, varied to suit different grades of ore and the different conditions under which the mixture is melted. Finally, it is advantageous to add some sawdust or crushed bituminous coal to the charge. This is consumed during the early stage of the smelting operation, and thus leaves the mass porous so that the smelting may proceed with greater rapidity. Some figures giving the exact proportions of various mixtures suitable for smelting were given on page 322 of our August issue.

The theory of the process is as follows: The pig or cast iron in the finely divided intimate mixture with the iron oxide has a double effect. First and primarily, the pig iron contains a high percentage of metalloids and generally manganese, which are presented to the oxide in the most intimate and effective condition possible, and therefore are active and ready reducing agents. Secondly, the fused pig iron appears to act simultaneously as a solvent for some of the free carbon and as an enveloping coat for the individual particles of oxide, thus bringing the dissolved carbon into intimate association with the oxide to supplement the reducing effect of the metalloids contained in the pig iron. The free carbon should be present in sufficient quantity to insure the proper carburization of the smelted metal, so as to maintain it in a fusible condition and also sufficient to protect the mixture against atmospheric oxidation.

In extended tests of the process, using both the electric furnace and the open-hearth, it has been found that practically the entire quantity of iron contained in the oxide as well as the entire quantity of pig iron added, was obtained in the molten product, the yield averaging 96 and 98 per cent.

The trials with the open-hearth furnace have been made and are still under way at the plant of the Carbon Steel Co., of Pittsburg. Heats from 10 to 15 tons have been made, the yield averaging about 96 per cent of the metallic matter charged.

The electric furnace trials were made at Niagara Falls by Messrs. FitzGerald and Bennie. In these trials the charges were made up of one-fourth pig and three fourths iron ore. The average yield from the metallic content charged was about 98 per cent. It is intended to test the new process in the Héroult electric furnace plant in Remscheid, Germany, and in the Stassano electric furnace in Italy. The process is also to be tested with Canadian magnetic concentrates on the Canadian side of Niagara Falls. The prediction is made that within the next few months the new companies will be able to produce by this process open-hearth steel at a cost of several dollars per ton less than is at present possible by using pig iron or pig iron and scrap.

The Detinning Suit.

On page 46 of our Vol. IV. we gave an account of the decision of Vice-Chancellor Bergen in the Court of Chancery of New Jersey, Newark, N. J., in the suit of the Vulcan Detinning Co. as complainant against the American Can Co. as defendant. The decision was in favor of the latter.

As was already noticed in our last issue this decision has now been reversed by the New Jersey Court of Errors and Appeals, the decision being delivered by Judge Garrison. Since it is a matter of great interest to see to what extent the courts go in protecting the discoverer of a secret process, we give below extended extracts from the decision, but will first give a summary of the facts in the case:

As early as 1891 the firm of Th. Goldschmidt, in Essen-Ruhr, operated an electrolytic process for detinning tinned iron scrap. A large part of the tin scrap treated was shipped to them from New York by A. Kern. The latter became impressed by the possibilities of erecting a detinning plant in this country and entered into negotiations with Goldschmidt's to get their process, but the latter declined. "In the course of this correspondence Dr Goldschmidt had in a letter of May 16, 1896, stated that his process was being used at Vlissingen, Holland, by a concern called the Tinfabriek, which had been organized by one Laernoes, who had clandestinely obtained the secret of the process."

For a party of New York merchants and manufacturers, among them Mr. Assmann, Mr. Kern bought from Laernoes the secret of the process for $200,000, and the latter came to this country to install the first plant of what is now the Vulcan Detinning Co. Mr. Assman as a director of this company had knowledge of the secret of the process. In 1901 he resigned, having become a director of the American Can Co. Shortly after the American Can Co. began the erection of two detinning plants, using the same process. The original suit was brought by the Vulcan Detinning Co. against the American Can Co. to enjoin the latter from using the process.

We now quote from Judge Garrison's decision:

"The learned Vice-Chancellor reached the conclusion that the process used by the Tinfabriek was a fraud upon the Goldschmidt's, of which Kern by reason of his correspondence with Dr. Goldschmidt in 1896 had knowledge, and that when Kern in 1898 became the agent of the corporators of the complainant, through whom the Tinfabriek process was acquired, the prior knowledge Kern had thus casually obtained must be imputed to the complainant under the decision of this court in the case of Willard vs. Denise. Having reached this conclusion as to the imputation of Kern's knowledge to the complainant, the Vice Chancellor further concluded that the effect of such imputation was to render the hands of the complainant unclean within that maxim of equity by which a deaf ear is turned to a suitor in a court of conscience regarding a matter in respect to which his own conduct has been unconscionable.

"In reaching this last conclusion the learned Vice-Chancellor fell, we think, into the error of ascribing an unconscionable status to the complainant by force of a presumption of remedial law that in its extreme application affects only the legal rights of parties and not at all their moral standing. That the knowledge possessed by an agent, but not acquired by

him while acting for his principal, will under certain conditions be imputed to the latter, is in the nature of a presumption indulged in by courts in working out the rights of litigating parties." * * * But "an essential part of the presumption in question is that the principal is ignorant of the knowledge that has been casually acquired by his agent; hence, by the hypothesis, the principal is not only ignorant of the knowledge thus acquired, but if such knowledge involves a fraud the principal is innocent of such fraud. True, he may be bound by it in the sense that his legal rights may be determined with reference to the knowledge with which he is thus chargeable, but his conscience is void of offense, and hence it cannot with any propriety be said that his hands are unclean; for 'unclean hands' within the meaning of the maxim of equity is a figurative description of a class of suitors to whom a court of equity as a court of conscience will not even listen, because the conduct of such suitors is itself unconscionable, i. e., morally reprehensible as to known facts."

Concerning the formation of the companies which are now the Vulcan Detinning Co., and their purchase of the secret from Laernoes, Judge Garrison says: "Of the good faith of the American corporators in the transaction which involved the payment of this large sum of money no legitimate doubt is raised by the testimony. Whether the prior knowledge possessed by Kern made his conduct fraudulent as to the Goldschmidts, so that in a suit brought by them such fraud would be imputable to these corporators, is a question that does not concern this present controversy. It should be noted, however, that there is a wide difference between the absolute secrecy which the discoverer of a process has the legal right to protect and the qualified secrecy which the complainant claims the equitable right to secure." * * *

"The main ground for relief disclosed by the complainant's case is the existence of inequitable competition arising from a breach of trust, and hence referable to general principles of equity and not to those special doctrines by which unpatented secrets are protected. In the application of these general principles the secrecy with which a court of equity deals is not necessarily that absolute secrecy that inheres in discovery, but that qualified secrecy that arises from mutual understanding and that is required alike by good faith and by good morals." * * *

"Entirely aside from the technical secrecy of the process or the abstract question of property therein, the complainant is entitled to have its trustees, his associates and their servants, restrained from using against the interests of the complainant the very process with which its trustee was entrusted for its benefit."

The question is then discussed at length whether the breach of trust committed by Assmann is chargeable to the American Can Co., and is answered in the affirmative. The criterion by which this question is to be answered is taken from an opinion of Mr Justice Dixon in a case of the State vs. Sooy: "The knowledge of the agent is chargeable upon his principal whenever the principal, if acting for himself, would have received notice of the matters known to the agent."

Concerning the license to work the process which the American Can Co. obtained from the Goldschmidts after the bill of complaint had been filed, Judge Garrison rules as follows:

"At the time the assignment was thus taken the defendants were fully apprised by the bill of complaint, if in no other way, of the precise nature of the complainant's claim to relief. The decision we have reached carries with it the defence that is thus sought to be set up under this assignment, upon the doctrine that if a trustee purchase a title that cures or completes one that he holds in trust, the presumption in equity will be that the later purchase was made in aid of the former trust." The Court of Appeals enjoined the American Can Co., but did not order an accounting, but sent the case back to the lower court for having the question of accounting determined.

CORRESPONDENCE

Detinning with Chlorine.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—On page 339 of your September issue of 1904, Dr. F. Winteler, summarizing the possible uses of electrolytic chlorine, calls attention to the detinning of tinned iron scrap with dry chlorine. He reminds us of the well-known behavior of dry chlorine gas on tin and iron at temperatures not exceeding 100° C., and proposes a process of detinning.

On Aug. 1 of the same year, F. von Kügelgen and G. O. Seward filed an application for a patent on a process of detinning with dry chlorine gas in an anhydrous solution, *e. g.*, stannic chloride. This patent (U. S. patent 783,726) was granted on Feb. 28, 1905. On May 29, 1900, Karl Goldschmidt and Josef Weber obtained a patent (U. S. patent 822,115) on practically the same process. This patent was followed by a second granted to the same petitioners on Sept. 16 of the same year (U. S. patent 831,223). The last-named patent protects a process of detinning tin scrap with dry diluted chlorine gas under altering pressure.

The fact that Dr. Karl Goldschmidt, member of the firm Theodor Goldschmidt, which operates so successfully the electrolytic process for detinning tin scrap, was engaged in experimenting on a purely chemical detinning process, called general attention to the chlorine detinning process. The knowledge of the fundamental reactions of these detinning processes with dry chlorine is very old. Not so well known, but probably of great interest to some of your readers, is the fact that chlorine detinning was already practiced in Europe on a commercial scale as early as 1873.

Prof. G. Lunge, describing the exhibition of the chemical works of Gebrüder Schnorf, Uetikon, in his *Bericht über Die Chemische Industrie auf der Schweizerischen Landesausstellung, Zürich*, 1883 (a report not easily accessible), writes on page 29:

"Very interesting is the process of detinning tin scrap. This process takes advantage of the inability of dry chlorine to attack iron, while it dissolves tin to stannic chloride. A cylinder, 1 meter in diameter and 4 meters high, has a tipping grade above the lower bottom on which the scrap rests. The chlorine gas enters underneath the grate and the fuming stannic chloride collects in a bottle placed underneath the cylinder. When the flow of tin chloride ceases the operation is stopped, the bottle and the underbottom are removed and the grate is tipped to remove the iron. The process may then be repeated as before. The tin scrap comes mostly from Cham, where tin cans are made on a very large scale for condensed milk.

"There is scarcely any commercial use for stannic chloride as such, but converted into solid chloride by judicious mixing with water and then further dissolving to solutions from 50° to 60° B., it is extensively used in silk dye factories. Since direct resmelting is not practiced in Switzerland, the iron is converted into sulphate of iron, of which 1,100 tons are produced yearly.

"It is very desirable that another use be found for the detinned scrap, especially as it consists of the richest and purest iron available, because the consumption of sulphate of iron does not go hand in hand with the quantity of detinned scrap produced."

I inquired of the "Chemische Fabrik Uetikon" (vormals Gebrüder Schnorf), and they informed me that the detinning of tin scrap as described above was practiced at their plant in Uetikon from 1873 to 1893. Low prices of tin and the decreasing tin content of the scrap rendered the process commercially impractical; 300 to 400 tons of tin scrap were detinned per year. The process was not a continuous one, every cylinder worked independently.

C. Offerhaus.

Anaconda, Mont.

A New Iron-Carbon Phase, Osmondite.

BY HENRY M HOWE

Professor of Metallurgy in Columbia University

Heyn and Bauer[1], ever skillful and indefatigable, have discovered a new and important iron-carbon phase, osmondite, which appears to be a solid solution of carbon (or of an iron carbide) in normal or alpha iron. Austenite, be it remembered, is such a solution in allotropic gamma iron. There is a certain fitness in linking together the memories of these illustrious and dear friends, Roberts-Austen and Osmond, by the names of these two substances so closely related by allotropy, the very subject which interested them in common so greatly, and, indeed, led to their friendship, if I mistake not.

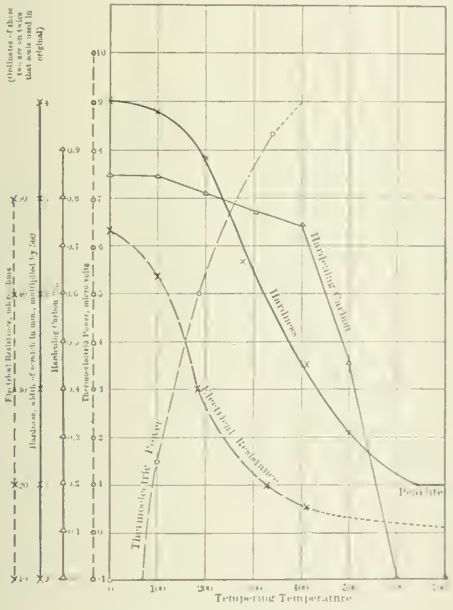


FIG. 1.—IN THE TEMPERING OF STEEL, THE CHANGES IN THE PHYSICAL PROPERTIES PRECEDE THE CHANGE IN CARBON CONDITION. (HEYN & BAUER AND BARUS & STROUHAL.)

(The dotted parts of the curves for electrical resistance and thermo-electric power are interpolated or extrapolated.)

This discovery by Heyn and Bauer was made in the course of their study of the nature and progress of the changes which occur in the tempering of hardened steel of 0.95 per cent of carbon, and therefore approximately eutectoid. Their procedure was first to harden a series of like pieces of this steel by quenching them from 900° C. in cold water; next to mitigate or "temper" the effects of this hardening by reheating these pieces severally to a series of temperatures ranging from 100° to 600°; and finally to determine their physical properties, their microstructure and the condition of their carbon.

I have prepared Fig. 1 so as to show simultaneously certain of their results, together with some of the probably comparable data of Barus and Strouhal which they recall.

That tempering changes the physical properties of hardened steel very greatly, and that it also changes the condition of the carbon from "hardening" or dissolved carbon, to "cement" carbon combined with iron as the definite iron carbide called "cementite," Fe_3C, has long been known. The important discovery now made is that the change in these physical properties precedes the change in the condition of carbon. Osmond[2] had indicated that as steel cools through the critical range, the change in physical properties precedes the change in carbon condition; and I had proved this fully,[3] but the conditions in this present investigation enable us to draw much firmer conclusions than were warranted by the earlier results of Osmond and myself.

Fig. 1 shows that, by the time that the tempering temperature has reached 400°, 70 per cent of the loss of hardness, 93 per cent of the loss of electric resistance, and nearly 100 per cent of the gain of thermo-electric power have taken place, whereas at most only 13 per cent of the change of the carbon from the dissolved or hardening to or towards the cementite state has occurred. In heating further to 600°, at least 87 per cent of the change of the carbon to the cementite state takes place. But this great change in carbon condition is accompanied by only 30 per cent of the loss of hardness, 7 per cent of the loss of electric resistance, and hardly any of the gain in thermo-electric power.

We should note that the whole argument rests, not on a certainty, but on what is only a reasonable probability. It rests on the reported condition of the carbon in these specimens, and this report in turn is based on the reasonable assumption that all of the carbon which escapes in the gaseous form when the steel is dissolved in 10 per cent sulphuric acid, with the air excluded, has been present in that steel as hardening carbon.

These results are in rough agreement with those of Dr H. C. Boynton,[4] who found that nearly the whole of the hardness was removed in tempering before reaching 500°, a temperature at which, according to Heyn and Bauer, only about half of the carbon has changed from hardening to cement. This then is a further indication that the loss of hardness outruns the change in carbon condition. Though these two sets of results agree in this essential matter, there are some considerable discrepancies between them. Thus the loss of hardness on reaching 400° was 70 per cent of the total according to Heyn and Bauer, but only 26 per cent according to Boynton, and the temperature of rapid softening was from 200° to 300° according to the former, but between 450° and 500° according to the latter. These differences may readily be due to differences in the methods of determining hardness and in the composition of the steels treated. Nevertheless, it is to be hoped that Dr Boynton may find it practicable to determine the carbon condition in his specimens, so as to establish more firmly the fact that the loss of hardness outruns the change from hardening to cement carbon.

In order to understand this matter clearly we should look back a little. Above the critical range (A_1 to A_2) the metal consists of a solid solution of carbon (or of an iron carbide) in the red-hot iron, and to this solid solution the name of "austenite" has been given. (See Fig. 2.) In case of the particular steel treated by Heyn and Bauer, this austenite is of the variety called "hardenite," i. e., it is of the eutectoid composition—about 0.95 per cent of carbon, and on this account it naturally undergoes only a single transformation in cooling through the critical range, viz.: the transformation called A_{r1}, at or about 670°. (S, Fig. 2.) This transformation is

[1] Über den inneren Aufbau gehärteten und angelassenen Werkzeugstahls, von Direktor Professor E. Heyn und Diplom-Ingenieur O. Bauer. Mitteilungen aus dem Königlichen Materialprüfungsamt Gross Lichterfelde West, 1906. See also Stahl und Eisen, 1906, XXVI., pp. 778, 915 and 991, and a most illuminating discussion by Osmond, to which I am much indebted: "Les Expériences du Prof. Heyn sur la Trempe et le Revenu des Aciers," Rev. de Metallurgie, III., Nov., 1906, pp. 621-632.

[2] Transformations du Fer et du Carbone, etc., pp. 28 and 87, 1888.

[3] The Hardening of Steel, Journal Iron and Steel Inst., 1895, II., p. 93 et seq.

[4] Hardness of the Constituents of Iron and Steel, H. C. Boynton, Journ. Iron and Steel Inst., 1906, II., pp. 315-317.

from the solid solution or austenite state to the state of pearlite, which is a mechanical mixture of alternate sheets of pure iron or ferrite and of the definite iron carbide, cementite, Fe_3C. If the metal is suddenly cooled while it is passing through this transformation, its condition after cooling is found to vary according to the degree to which that transformation had taken place at the instant when the sudden cooling began; so that sudden cooling seems to preserve more or less accurately the condition which exists at the moment when the transformation is thus interrupted. In this way we have found that the metal passes through successive well marked stages, to which the names martensite, troostite, and sorbite have been given; and to these osmondite is now added. These stages might represent definite phases; or, shading off imperceptibly into each other, they might be only extremely fine mechanical mixtures of such phases. Table I. gives these successive stages and their conjectured constitution:

Table I.—The Stages of the Transformation from Austenite into Pearlite.

Name.	*Constitution.*
Austenite	Solid solution of an iron carbide (hardening carbon) in gamma iron.
Martensite, a transition substance.	The same, with some of the gamma iron changed to beta and to alpha iron. Its most valuable property, its great hardness, is probably due to its beta iron.
Troostite, a transition substance.	The same, the quantity of gamma and beta iron constantly decreasing, that of alpha iron constantly increasing.
Osmondite	Solid solution of iron carbide (hardening carbon) in alpha iron.
Sorbite, a transition substance.	A mixture of a constantly decreasing quantity of osmondite with a constantly increasing quantity of pearlite, too fine to be resolved by the microscope.
Pearlite	A conglomerate or mechanical mixture of free alpha iron (alpha ferrite) with the iron carbide, Fe_3C, cementite.

Note to Table I.—Thus there appear to be three definite stages, the end ones, austenite and pearlite, and the midway stage, osmondite; and three intermediate indefinite stages of varying composition, martensite, troostite, and sorbite.

The austenite here referred to is "typical austenite," i. e., the austenite as it exists in the hot steel above A_3. It is never found in its typical or pure state in the cold, because, even under the most favorable circumstances, viz.: when a very high-carbon steel is cooled extremely rapidly from well above A_3, some of the gamma iron always changes into beta, and even into alpha iron, as is shown by the strong magnetic properties of this steel. The cold austenite, therefore, is really intermediate in composition between typical austenite and martensite, in spite of the fact that austenite and martensite in a given specimen of cold steel are often sharply distinguishable from one another. This simply means that, in such specimens, there are, side by side, microscopic regions in which the transforation from austenite towards pearlite has gone far, and others in which has only begun. The former are true martensite, the latter are justly called austenite, because in them the transformation has not yet gone far; quite as a felspar which has only just begun to degenerate into clay is still reasonably called felspar.

French writers, indeed, usually restrict the term "austenite" to that found in the cold steel, and call typical austenite, i. e., the solid solution as it exists above A_3, "gamma iron" (fer gamma).

The strongly marked needles so characteristic of cold martensite probably represent the structure of the true or typical austenite, from which it has sprung, because Saniter developed this same structure by etching steel when it was above A_3, and when it therefore by definition consisted of typical austenite. (Journ. Iron and Steel Inst., 1897, II., p. 128, Plate V., Figs. 2 and 3.) Thus a possible basis of definition of martensite might be "austenite, which is so slightly transformed as to show traces of acicular structure"; though this would lose sight of the most striking and valuable property of cold martensite, its extreme hardness, due probably to its large content of beta iron.

This present proof, that in tempering, very marked changes in the physical properties precede the change in the condition of carbon, has certain very important consequences. In the first place it indicates that the allotropic change in iron, which has been known since the remote historic day when Gilbert discovered that red-hot iron was not magnetic, is in itself the chief cause of the hardness of hardened steel; because this change in the properties of the steel which precedes the change in carbon condition can hardly be due to anything other than this sufficient cause, this known allotropic change in the iron itself. M. Osmond's earlier results and mine did not prove this, because the change in the properties of our non-eutectoid steel might have been due to the gradual separation of ferrite from the austenite which is known to occur before the change in carbon condition; whereas in the eutectoid steel of Heyn and Bauer there should be no such separation of ferrite from the austenite before the change in carbon condition.

In the second place, it puts before us the fact that, during the interval between the change of the iron from the allotropic to

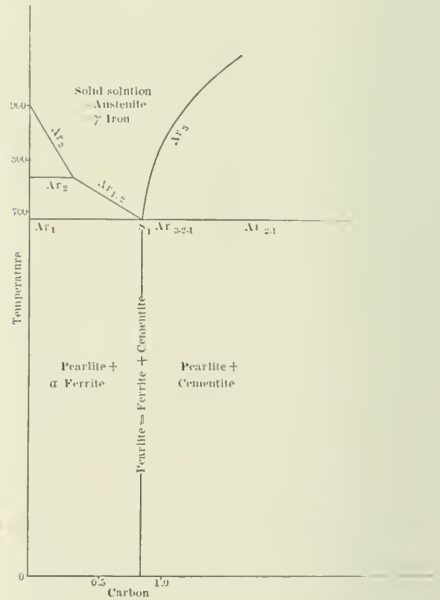


FIG. 2.—PART OF ROBERTS-AUSTEN OR IRON CARBON DIAGRAM.

the normal or alpha state, and that of the carbon from the hardening or dissolved to the cementite or carbide state, that carbon must be dissolved in that alpha iron.[5] Here, then, we are brought face to face with a new entity, a new phase, carbon dissolved in alpha iron. What shall it be called? Differing as it does from austenite in having its iron in the alpha instead of in the gamma state, it might have been called alpha austenite. But its discoverers have exercised their undoubted right to give it a proper name, calling it osmondite; and in this they have done wisely in my opinion.

What are the physical properties of this osmondite? From the conditions of its existence we can hardly expect ever to isolate it in the pure state, if indeed ever to identify it posi-

[5] Carbon itself, that is to say free or elemental carbon, seems to be nearly insoluble in alpha iron. (See Journal Iron and Steel Inst., 1906, IV., p. 543, foot note.) Therefore, the dissolved carbon of the osmondite is likely to be, not elemental or free carbon, but an iron carbide, and if this is true of the carbon of the osmondite, it is probably true of that of the austenite whence the osmondite is derived. Here, then, we have an additional reason for regarding austenite as a solution, not of free carbon, but of an iron carbide, in gamma iron.

tively under the microscope, because it will always be mixed with the products of its own decomposition. But if its properties are well marked, we may hope to detect them in one way or another. For instance, if we take a series of tempered pieces, each tempered at a slightly higher temperature than the preceding, we find, first, that the rapidity of dissolving in dilute sulphuric acid, and, second, the intensity of coloration caused by etching with alcoholic hydrochloric acid, reach a maximum in the specimen tempered at 400°, and decrease as the tempering temperature departs from 400° either upwards or downwards. Are these two properties, which reach their maximum about simultaneously with the osmondite, properties of that osmondite? Let us consider. As that substance comes into existence, so simultaneously does a certain quantity of the carbon slip from the dissolved or hardening into the cementite state; because these transformations do not follow each other in single file like a line of soldiers, but overlap, so that while certain molecules are slipping from the martensite into the osmondite stage, certain others are simultaneously slipping from the osmondite through the sorbite into the pearlite stage. Now, the first particles of cementite thus born are sure to be much more finely divided than the mass of cementite later on, when, with further rise of temperature and the accompanying greater freedom of motion, its particles coalesce into larger masses. For instance, Heyn and Bauer find, beside the hardening carbon which escapes as gas when the metal is dissolved in extremely dilute sulphuric acid, and the cementite which is found as such in the residue from that dissolving, some additional carbon in that same residue. This may indeed represent the dissolved or solid-solution carbon of the osmondite, or a part of that carbon; but, on the other hand, as Osmond justly points out, it may represent simply the carbon of some cementite so finely divided that it is decomposed even by this weak sulphuric acid, with precipitation of its carbon in the residue.

Thus it may well be that this maximum rapidity of dissolving in sulphuric acid, and this maximum depth of coloring on etching in alcoholic hydrochloric acid, which characterize steel tempered at 400°, are due, not to the presence of osmondite, but to the finely divided condition of the almost nascent cementite or to some other special state of aggregation. Nevertheless, we have here a strong suggestion that these properties do belong to the osmondite, and a hint to future investigators to seek a definite answer to the question whether they do or do not.

But there are two properties of osmondite, its electric resistance and its hardness, as to which we may form firmer opinions, as I will now show.

From the fact that the increase of electric resistance caused by hardening is removed almost wholly by the time that the very richly osmonditiferous stage is reached, viz.: by the time that the tempering temperature reaches 400°, it is extremely probable that the electric resistance of osmondite is not much greater than that of pearlite.

That osmondite is much softer than martensite is, indeed, but one face of the reasoning which leads us to postulate the very existence of osmondite. We say that the loss of 70 per cent of the hardness in the 400°-tempered specimen is too great to be explained by the transfer of only 13 per cent of the carbon from the dissolved or hardening to the cementite state; that it implies the existence of a phase which is soft in spite of having its carbon in the dissolved state, and this soft phase we call osmondite. But beyond this we cannot go. We cannot say whether the still very considerable excess of hardness in the osmonditiferous 400°-tempered specimen over the hardness of pearlite is due to the greater hardness of osmondite than of pearlite, or to the martensite still remaining. In short, while osmondite is thus softer than martensite, we cannot tell how its hardness compares with that of pearlite.

The inequiaxing of osmondite remains to be studied. By inequiaxing I refer to the distortion or deformation of the crystalline grains of the metal, which normally are equiaxed. And right here let us consider the four means by which the sudden cooling of the hardening process may affect the properties of the metal. These are:

(1) Retaining the carbon in the hardening condition, labile below A_1.

(2) Preserving the iron in either or both of the allotropic states, beta and gamma, both labile below the critical range.

(3) Setting up permanent stress.

(4) Inequiaxing or distorting (ecrouissant) the crystalline grains, through differences in the contraction of different layers, due in part to differences in their rates of cooling and consequent contraction (æolotachie contraction, *i. e.*, different in rate even if equal in quantity), and in part to the different degrees to which the above transformations (1) and (2) and their consequent changes of volume (contraction differing in quantity) take place in the different layers.

There is a nearly general agreement that the second of the above four causes is the chief agency in the hardening of steel; but so talented an investigator as M. A. Le Chatelier assigns very great importance to the fourth, while the first cause seems to me to contribute powerfully, from the fact because it is only in the presence of much carbon that we ever get such extreme mineralogical hardness as that of hardened high carbon steel.

To this inequiaxing, M. Osmond calls attention. In order to understand the matter we should remember that the strengthening, embrittling, and hardening effects of processes like wire-drawing and cold rolling on the malleable metals and alloys in general are probably due chiefly to the distortion or inequiaxing which these processes cause, and that the removal of these effects which annealing causes is probably due to its re-equiaxing the metal, restoring it to its initial state. Prof. Heyn[6] has lately thrown invaluable light on this question, by showing that, in the annealing of hard-drawn wire, the equiaxing begins at 400° and completes itself when 600° is reached; and that simultaneously with this equiaxing the chief part of the weakening and toughening effects of the annealing take place.

From this fact that the inequiaxing of wire-drawn steel persists in chief part until the tempering temperature passes beyond 400°, it is extremely probable that the inequiaxing which hardening causes also persists in chief part up to this same 400°, so that not only the austenite, martensite, and troostite of hardened steel, but also the troostite and osmondite of tempered steel, are inequiaxed.[7]

M. Osmond lays great stress on this, and would base on it an estimate of the degree to which the effects of hardening by sudden cooling are due to inequiaxing as distinguished from the retention of allotropic iron and hardening carbon. He seems to attribute the properties of osmondite chiefly to its inequiaxing, and only in small part to its containing hardening carbon. But it seems to me that we do not know enough about its properties to be justified in doing more than speculate very tentatively about their cause. It is true that the fact that the electric resistance of the osmonditiferous 400°-tempered specimen is but slightly greater than that of pearlite, agrees well with the fact that the inequiaxing of wire drawing affects the electric resistance only slightly, and is wholly consistent with the belief that the properties of osmondite are due to its inequiaxedness. But the very vagueness of our knowledge of how hard osmondite is prevents our forming any strong opinion as to the source of its hardness. If we should later discover how hard osmondite really is, and if we should then find that its hardness exceeds that of pearlite to a degree which

[6] Über die Nutzanwendung der Metallographie. Stahl und Eisen, 1906, XXVI., pp. 1080-97.

[7] Needless to say, this inequiaxing is true neither of austenite as it exists in the red-hot steel above the critical range, before sudden cooling begins, nor of these other stages, martensite, etc., as they are successively entered during slow cooling, if, indeed, they then are entered, instead of being skipped over.

correspond roughly to the mild hardening which wire drawing and other forms of inequiaxing cause, then we should be inclined to attribute that hardness to the inequiaxing of the cementite. But if we should find that the hardness of cementite exceeds that of pearlite to a much greater degree, then we should incline to refer much of its hardness to its containing hardening carbon.

Invoking the inequiaxing or distortion incidental to the hardening of steel by sudden cooling to explain its marvellous effects has always seemed to me to lack cogency; first, because the most pronounced effect of this sudden cooling is the astonishing increase in mineralogical hardness, a property on which distortion as we know it in wire drawing has relatively little effect; and, second, because if distortion were the true cause or an important cause, then sudden cooling ought to cause like effects at least in certain other alloys. But if there is any other alloy in which it causes effects at all comparable with the hardening of steel, I do not know it.

Rapid and Accurate Gas Analysis.

By Edwin Barnhart,

Chemist, By Product Coke Plant, Maryland Steel Co.

Owing to the number of analyses of gases required daily and the amount of time consumed an apparatus giving rapid and accurate results was very desirable.

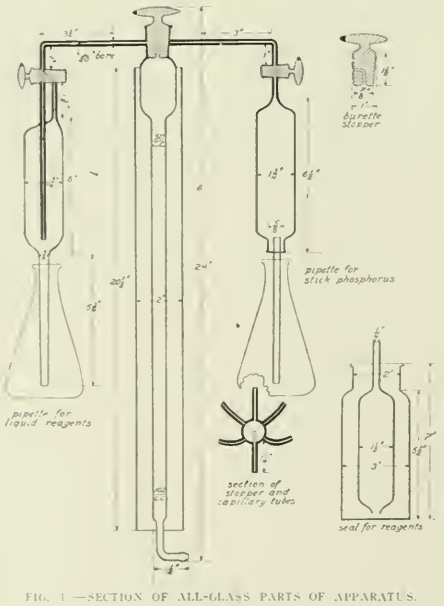


Fig. 1.—Section of All-Glass Parts of Apparatus.

Formerly the following two well-known types of apparatus were used:

The Orsat Muncke apparatus was used for the analysis of blast furnace, producer and flue gases, while for the illuminating and fuel gases from coke ovens the latest modification of the Hempel apparatus was used, a higher degree of accuracy being essential in this work.

Those familiar with the Hempel apparatus will agree that skillful manipulation is necessary; also the consumption of a greater amount of time is required than with other types of apparatus, while the Orsat apparatus, requiring less skill and time for manipulation, has a limited application.

The apparatus described in this article is designed for the classes of work before mentioned, and gives a high degree of accuracy while requiring a minimum amount of time.

This special apparatus, as designed by N. M. Randall and the writer, was made by Eimer & Amend, New York, about two years ago, and has been in constant use here since. It has given entire satisfaction and filled every requirement.

The time required for a complete analysis of coal or producer gas with this apparatus is about 20 minutes, and under favorable conditions this time has been reduced to 15 minutes. This is a performance worthy of special note.

Numerous requests having been made for a description of this apparatus, I have prepared this brief article, believing that the apparatus represents an improvement in the method of gas analysis worth recording.

Fig. 1 shows the section of all the glass parts of the apparatus. Fig. 2 shows the mahogany support and mounting for the apparatus. Fig. 3 is a front view with the explosion pipette detached. Fig. 4 is a front view with the explosion pipette attached. Fig. 5 is a rear view of the apparatus, showing the device for sealing the reagents from the atmosphere. Fig. 6 is a view of the top of the burette, showing the pipette connected.

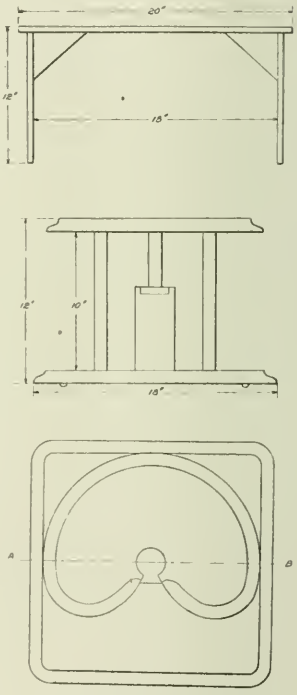


Fig. 2.—Section of Support for Apparatus.

The measuring burette is of 100 c. c. capacity, the narrow part of which is graduated from 102 c. c. at the bottom to 50 c. c. just below the wide part, and is subdivided into 1/10 c. c. or 1/20 c. c. The burette has a white back with a blue strip, to facilitate accurate reading. The bottom of the burette terminates with a narrow tube for a rubber connection with a leveling bottle. Between the burette and the leveling bottle is a stop-cock, to facilitate manipulation. The upper end of the burette terminates in a bottle-neck fashion, which forms the casing for a plug or stopper.

On the outer circumference of this casing are six capillary tubes 1½ inches in length, which communicate with the burette when the stopper is in the proper position. By this feature six, or a less number, of absorption pipettes may be directly connected with the burette, thus eliminating the long header capillary of the Orsat apparatus, which gives rise to an error in measurement after absorption. This feature also eliminates changing of pipettes during the process of analysis, as is necessary with the Hempel apparatus.

In the event of an accumulation of dirt or grease in the burette the stopper may be removed and the burette swabbed out without disconnecting any part of the apparatus.

The stopper in the top of the burette revolves easily, fits perfectly and has never caused the slightest inconvenience.

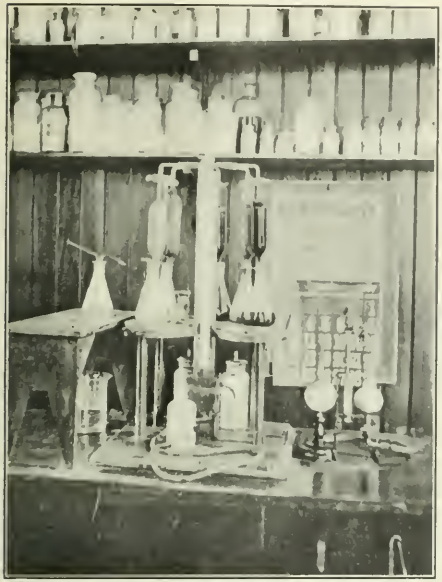


FIG. 3.—FRONT VIEW WITH THE EXPLOSION PIPETTE DETACHED.

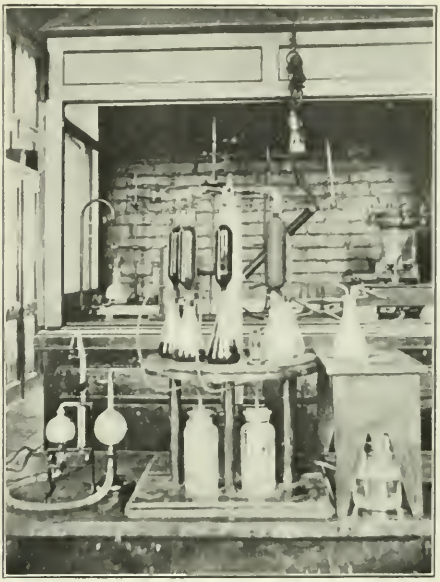


FIG. 5.—REAR VIEW, SHOWING DEVICE FOR SEALING THE REAGENTS FROM ATMOSPHERE.

FIG. 4.—FRONT VIEW WITH THE EXPLOSION PIPETTE ATTACHED.

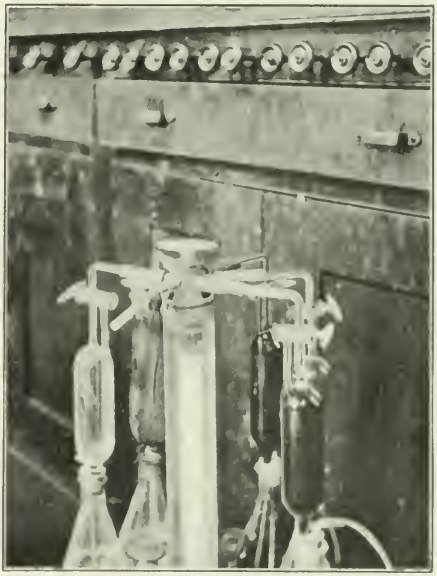


FIG. 6.—TOP OF BURETTE, SHOWING THE PIPETTE CONNECTED.

The pipettes for liquid reagents shown in Fig. 1 have numerous advantages. The gas being caused to pass through the reagents is most rapidly absorbed. The pipettes are duplicates, and may be interchanged if necessary. The pipette proper terminates with a narrow tube, which is neatly fitted into an 8-ounce Erlenmeyer flask by means of a doubly perforated stopper, the flask making a support for the pipette, and acting as a reservoir for the reagent. The renewal of the reagent is accomplished by simply removing the flask and refilling, the capacity of the flask exceeding that of the pipette.

Stick phosphorus being a very good absorbent for small quantities of oxygen, the pipette shown on the drawing is used

for that purpose, the pipette proper being covered with black linen to protect the phosphorus from the light.

The reagents are protected from the atmosphere by the device shown on the drawing, which consists of a wide-necked bottle, which admits a tube drawn to a small opening at both ends, the upper end terminating with a narrow tube which passes through a doubly perforated rubber stopper in the bottle and connects with the flask containing the reagent by means of a rubber tube. The capacity of this tube is about 150 c. c., when the proper amount of water is placed in the bottle (about 125 c c) the sealing of the reagent requires no more attention.

For the determination of methane and hydrogen the Hempel mercury pipette is used.

The apparatus is supported upon a neat and substantial mahogany frame, which is shown in Fig. 2, of which the lowest diagram is a plan while the middle diagram shows the section at line A-B, and the upper diagram represents a neat mahogany bench, which is placed in front of the apparatus to support the mercury pipette when attached; it is also used when gas samples are taken into the apparatus from a collecting tube or bottle.

The base of the wooden frame is 18 inches square, in the center of which is a cylindrical block 6 inches high and 3 inches in diameter; upon this block the burette and jacket are supported; 10 inches above the base and fastened to it by five 1-inch rounds is the support for the pipettes and flasks. This also keeps the burette and jacket in an upright and rigid position. The apparatus thus mounted may be moved very conveniently. The part of the frame upon which the Erlenmeyer flasks rest is covered with a thin sheet of black paranite.

Supposing the sample under examination to be coal gas, the method of precedure would be as follows:

100 c. c. of gas is admitted to the measuring burette through capillary in front, the reading immediately taken and the gas passed into the first pipette on the left containing sodium hydrate. The second pipette contains sodium hyrogallol, the third bromine water, the fourth ammoniacal cuprous chloride, and the fifth to remove the ammonia and the last traces of carbon monoxide contains an acid solution of cuprous chloride. After the volume of carbon monoxide has been noted the residual gas is confined over the acid solution.

88 c. c of air is now admitted to the burette, 12 c. c. of the residual gas mixed with it, and mixture exploded over mercury in the Hempel pipette; the contraction noted and the carbon dioxide formed absorbed with sodium hydrate.

The following two analyses show a comparison of work done with this apparatus with that done with Hempel's apparatus, No. 1 being made with the Hempel:

	No. 1.	*No. 2.*
Carbon dioxide	2.05%	2.10%
Oxygen	.10	.05
"Illuminants"	4.30	4.25
Carbon monoxide	6.90	7.00
Methane	36.50	36.71
Hydrogen	44.25	44.27
Nitrogen	5.90	5.62

Analysis No. 2 required 20 minutes for completion.

The following analyses are the work of two men, a portion of the same gas and the same apparatus being used by each:

	No. 1.	*No. 2.*
Carbon dioxide	2.80%	2.80%
Oxygen	.60	.60
"Illuminants"	2.60	2.40
Carbon monoxide	6.80	6.80
Methane	32.14	30.90
Hydrogen	45.14	46.20
Nitrogen	9.92	10.30

Both of the above analyses required 16 minutes for completion.

Metallurgical Calculations.

By J. W. Richards, Ph. D.
Professor of Metallurgy in Lehigh University.

"Bringing Forward" of Copper Matte.

The above term is the old Welsh expression for the further treatment of mattes which gradually eliminates iron and sulphur and finally results in "crude" or "blister" copper, usually 90 to 99 per cent pure. The matte obtained by the first smelting operation varies considerably in richness, between 20 and 50, or even up to 60, per cent of copper. The reason it is not always made high in copper is that the richer the matte the more copper goes into the slag: one of the expert metallurgist's best accomplishments in copper smelting is to make a rich matte and poor slag. The making of slag of the best composition, and the use of extra large settlers or fore-hearths, helps most to this end. Having then this "first matte" the problem of the metallurgist is to get from it the metallic copper which it contains.

The Welsh Process.

The principle employed is to partially roast the matte and then to smelt it down to a richer matte and a ferruginous slag. The grade of matte formed in this smelting depends entirely upon the amount of roasting to which the matte has been subjected, the more sulphur eliminated by roasting the less can be present to form matte and the richer the matte.

Illustration: A matte containing 21.36 per cent of copper and 22.95 per cent of sulphur is roasted until its sulphur contents is two-thirds eliminated. What grade of matte can be expected on the subsequent smelting?

The sulphur left is $22.95 \div 3 = 7.65$. The 21.36 of copper requires 5.34 of sulphur to form Cu^2S, leaving $7.65 - 5.34 = 2.31$ of sulphur to form FeS. This forms $2.31 \times 88/32 = 6.35$ FeS. The resulting matte cannot contain more FeS than this; its composition will therefore be approximately:

Copper	21.36	= 64 per cent.
Iron	4.04	= 12 "
Sulphur	7.65	= 23 "
	33.05	

In practical work a richer matte than this will be formed in reverberatory furnace smelting and a slightly poorer matte by shaft furnace smelting, because in the former there is some reaction between the oxides and sulphides of the roasted ore, resulting in an expulsion of SO^2 during smelting, and in the latter, using carbonaceous fuel, the temperature is so high and reducing action so strong that metallic iron is formed and enters the matte, practically acting as if the matte contained some Fe^2S, and thus diluting the matte.

This roasting is a slow operation unless the matte is crushed and roasted fine. Lump matte is very little pervious to gases; it roasts slowly. By breaking a lump in half we, on an average, increase its surface 50 per cent, and therefore the exposed surface available for oxidation increases, for a given weight of material, very quickly as its size is decreased. For auto-roasting by its own self-generated heat of oxidation the finer the better, and roasting thus in lump form is impracticable because of the slowness of the operation.

Pyritic smelting of matte is probably altogether out of question as far as pure pyritic smelting without carbonaceous fuel is concerned. Using some coke, however, an oxidizing smelting analagous to partial pyritic smelting is possible, as was proved by Mr. Freeland, at Isabella, Tenn. Such a concentrating pyritic smelting is more feasible with a low-grade matte than with a high grade, because there is more iron and sulphur to oxidize. It will be profitable to calculate closely the details of this matte smelting to rich matte, and to compare it with the details of the smelting of raw ore in the same furnace—the subject of Problem 107 (July issue).

Problem 109.

W. H. Freeland, at Isabella, Tenn. (see *Engineering and Mining Journal*, May 2, 1903), smelted a low-grade matte without preliminary roasting in a water-jacketed Herreshoff furnace, having a free area at the tuyeres of 21.7 square feet. The analyses of materials used and the products are as follows:

	Charges.					
		Raw	*Laboratory*			
	Matte	*Ore.*	*Samplings.*	*Slags.*	*Quartz.*	*Coke.*
Cu	20.00	2.79	2.45	0.73	.....	.....
Fe	47.15	43.26	31.07	39.20	1.45	2.30
S	24.00	29.18	14.84	1.75	0.32	1.58
SiO^2	0.44	10.01	22.66	30.90	96.79	8.41
CaO	0.10	6.32	5.71	8.51	0.23	.....
MgO	.....	1.39	2.03	2.71	.....	.....
Zn	2.05	2.50	2.05	2.88	.....	0.00
Al^2O^3	0.82	1.00	1.15	1.90	0.32	3.56
Mn	0.53	0.69	0.75	0.85	.....	0.00
O	4.91	.....	3.30	11.37	0.38	1.00
C	.....	.....	13.90	.....	.....	83.86
CO^2, etc.	.....	2.80	.....	.....	.....	.....
Loss	.....	.....	.....	.....	0.39	.....

	Products.		
	Matte.	*Flue Dust.*	*Slags.*
Cu	49.63	2.49	0.60
Fe	25.24	24.79	43.99
S	23.00	8.91	1.19
SiO^2	0.26	31.43	33.72
CaO	.....	3.31	2.03
MgO	.....	1.18	0.57
Zn	1.53	3.81	2.12
Al^2O^3	.....	3.93	2.16
Mn	0.39	0.30	0.50
O	.....	3.07	12.86
C	.....	15.88	.....

The charges and products per 24 hours and per 1,000 of matte used were:

Charges:		
Matte	47.5 tons	1,000 lbs.
Raw ore	8.1 "	170 "
Laboratory samplings	1.6 "	34 "
Slag	7.6 "	160 "
Quartz	15.7 "	330 "
Coke	4.5 "	95 "
Products:		
Matte	19.1 tons	401.6 lbs.
Flue dust	0.6 "	12.0 "
Slag	56.1 "	1182.2 "

Blast applied, 4,500 cubic feet displacement, at 17 ounces pressure. Assume temperature of gases 450° C., and that they contain no CO, SO^2 or free O^2 (no analyses are given). Assume matte and slag issuing from the furnace at 1,300° C. (no temperature is given).

Required:

(1) A balance sheet of everything entering and leaving the furnace.

(2) The volume efficiency of the blowing plant.

(3) The heat generated per minute per square foot of cross-section in the focus of the furnace.

(4) The theoretical temperature at the focus.

(5) The proportion of the heat generated in the focus by the combustion of carbon and by the oxidation of sulphides.

(6) The concentration effected in this smelting.

(1) **Balance Sheet** (*per 1,000 of matte smelted*).

Charges.		*Matte.*	*Flue Dust.*	*Slag.*	*Gases.*
Matte (1,000)					
Cu	200.00	199.31	0.30	0.39	.....
Fe	471.50	101.36	2.97	367.17	.....
S	240.00	92.18	.....	.....	147.82
SiO^2	4.40	1.64	.....	3.36	.....
CaO	1.00	.....	.....	1.00	.....
Zn	20.50	0.14	.....	14.36	.....
Al^2O^3	8.20	.....	.....	8.20	.....
Mn	5.30	1.57	.....	3.73	.....
O	49.10	.....	.....	45.10	.....
Ore (170)					
Cu	4.74	.....	.....	4.74	.....
Fe	73.54	.....	.....	73.54	.....
S	49.60	.....	1.07	14.15	34.38
SiO^2	17.02	.....	3.77	13.25	.....
CaO	10.74	.....	0.40	10.34	.....
MgO	2.36	.....	0.14	2.22	.....
Zn	4.35	.....	0.46	3.89	.....
Al^2O^3	1.70	.....	0.47	1.23	.....
Mn	1.17	.....	0.04	1.13	.....
O	2.40	.....	.....	2.40	.....
CO^2	2.38	.....	.....	.....	2.38
Samplings (34)					
Cu	0.83	.....	.....	0.83	.....
Fe	10.56	.....	.....	10.56	.....
S	5.05	.....	.....	.....	5.05
SiO^2	7.70	.....	.....	7.70	.....
CaO	1.04	.....	.....	1.04	.....
MgO	0.69	.....	.....	0.69	.....
Zn	0.70	.....	.....	0.70	.....
Al^2O^3	0.39	.....	.....	0.39	.....
Mn	0.26	.....	.....	0.26	.....
O	1.15	.....	0.48	0.67	.....
C	4.73	.....	1.91	.....	2.82
Slags (160)					
Cu	1.17	.....	.....	1.17	.....
Fe	62.72	.....	.....	62.72	.....
S	2.80	.....	.....	.....	2.80
SiO^2	49.44	.....	.....	49.44	.....
CaO	13.62	.....	.....	13.62	.....
MgO	4.34	.....	.....	4.34	.....
Zn	4.61	.....	.....	4.61	.....
Al^2O^3	3.04	.....	.....	3.04	.....
Mn	1.36	.....	.....	1.36	.....
O	16.90	.....	.....	16.90	.....
Quartz (330)					
Fe	4.78	.....	.....	4.78	.....
S	1.06	.....	.....	.....	1.06
SiO^2	319.41	.....	.....	319.41	.....
CaO	0.76	.....	.....	0.76	.....
Al^2O^3	1.06	.....	.....	1.06	.....
H^2O	2.93	.....	.....	.....	2.93
Coke (95)					
Fe	2.19	.....	.....	2.19	.....
S	1.50	.....	.....	.....	1.50
SiO^2	7.99	.....	.....	7.99	.....
Al^2O^3	3.38	.....	.....	3.38	.....
C	79.67	.....	.....	.....	79.67
H^2O	0.27	.....	.....	.....	0.27
Blast (2,005)					
O^2	476.03	.....	.....	81.24	395.30
N^2	1588.77	.....	.....	.....	1588.77
	3854	401.60	12.01	1176.05	2264.84

Notes on the Balance Sheet.

The sulphur and carbon of the charge passing into the gases are, from the balance sheet, 192.61 and 82.40, respectively. We can assume all the carbon in the gases as CO^2 and all the sulphur as SO^2 except, say, half of that from the ore. This

leaves 192.61 — 17.19 = 175.42 of sulphur to be oxidized at the focus:

$$\text{Oxygen for sulphur} = 175.42 \times \frac{32}{32} = 175.42$$

$$\text{Oxygen for carbon} = 82.49 \times \frac{32}{12} = 219.97$$

Total to burn sulphur and carbon at focus 395.39

$$\text{Oxygen for Fe in slag} = 499.31 \times \frac{16}{56} = 142.66$$

$$\text{Oxygen for Mn in slag} = 6.48 \times \frac{16}{55} = 1.88$$

$$\text{Oxygen for Zn in slag} = 23.50 \times \frac{16}{65} = 5.77$$

Total in slag 150.31

Total oxygen in gas and slag = 545.70
Oxygen furnished by solid charges 69.07

Oxygen furnished by the blast 476.63
Nitrogen furnished by the blast 1588.77

(2) The furnace receives 2,065 pounds of blast per 1,000 of matte concentrated. This represents at 0°:

$$\frac{2065 \times 16}{1.293} = 25{,}550 \text{ cubic feet.}$$

Per 2000 lbs. matte = 51,100 " "
Per 47.5 tons matte = 2,427,250 " " per day.
= 101,135 " " " hour.
= 1,686 " " " minute.
At 50° C. = 1,958 " " " "
Blower displacement = 4,500 " " " "

$$\text{Efficiency of blower} = \frac{1{,}958}{4{,}500} = 0.435 = 43.5 \text{ per cent.} \quad (2)$$

(3) To calculate the heat generated at the focus we will assume that all the fixed carbon of the coke is there burned to CO^2, and that the rest of the oxygen blown in produces the reaction characteristic of pure pyritic smelting. There is treated per minute:

$$\frac{47.5 \times 2000}{1440} = 66 \text{ lbs. of matte,}$$

and the carbon burned per 1000 of matte is 82.49 lbs., generating

$$82.49 \times 8100 = 668{,}169 \text{ lb. Calories,}$$

and absorbing 219.07 lbs. of oxygen. This leaves 476.63 − 219.07 = 256.66 lbs. of oxygen to oxidize sulphides.

Since by the "pyritic smelting" reaction, $2O^2$ generates 161,560 calories, there is generated per pound of oxygen thus used

$$161{,}560 \div 64 = 2{,}524 \text{ lb. Calories,}$$

and per 1000 lbs. of matte smelted we have

$$2{,}524 \times 256.66 = 677{,}820 \text{ lb. Calories,}$$

but heat generated by carbon = 668,170 " "

Total = 1,345,990 " "

Since this is per 1000 lbs. of matte smelted, we have, per minute

$$1{,}345{,}990 \div 1{,}000 \times 66 = 88{,}835 \text{ lb. Calories,}$$

and per square foot of smelting zone area, per minute

$$88{,}835 \div 21.7 = 4{,}094 \text{ lb. Calories.} \quad (3)$$

Comparing this with the 732,930-pound Cal. generated at the focus in smelting 1,000 pounds of ore, and the 3,575-pound Cal. there generated per square foot per minute, we see that the matte smelting requires more heat per unit of charge, principally because the smelting is done more slowly. Radiation losses are over twice as great per unit of charge treated when concentrating matte than when ore concentrating. This points to the utility of hard driving when smelting matte, as the direction likely to yield greatest economy.

(4) Taking as a basis of calculation 1,000 pounds of matte treated, there is generated at the focus 1,345,990-pound Cal., there is used 2065 pounds of blast, and there arrives at the focus all of the charges except the flue dust, CO^2 and H^2O of charges, and approximately one-half of the sulphur contained in the raw ore. We therefore have arriving at the focus approximately:

82.5 lbs. of fixed carbon.
1133.0 lbs. of sulphides.
545.0 lbs. of inert slag-forming material.

These come to the focus preheated by the ascending gases, and assuming them to be preheated to 1,000°, we can find the correction to be used for their sensible heat:

Carbon	$82.5 \times 380 =$	31,350 lb. Calories.
Sulphides, melted	$1133.0 \times 200 =$	226,000 " "
Slag-forming material	$545.0 \times 174 =$	94,850 " "
		352,200 " "
Heat generated at the Focus		1,346,000 " "
Total in the hot products, at Focus		1,698,200 " "

Letting t be the theoretical temperature at the focus, then we have:

Heat in Slag $1176[300 + (t - 1100)0.27]$
" " Matte $402[200 + (t - 1000)0.14]$
" " S vapor $17[179 + (t - 445)0.11]$
" " SO^2 $\frac{351}{2.88}[0.36t + 0.0003t^2]$
" " CO^2 $\frac{302}{1.96}[0.37t + 0.00022t^2]$
" " N^2 $\frac{1589}{1.26}[0.303t + 0.000027t^2]$

The calorific capacity of these products at t° is therefore

$$29{,}858 + 858.7t + 0.1046t^2$$

and making this equal to the heat available at the focus, we have

$$0.1046t^2 + 858.7t + 29{,}858 = 1{,}698{,}200$$

whence $t = 1622°$. (4)

This is 53° higher than we calculated for the same furnace smelting ore, with only one-third as much coke. If the coke were omitted from this charge the theoretical temperature would be:

$$t = 1388°.$$

Such a theoretical temperature at the focus would not suffice to form slag, supply radiation and conduction losses, and see the matte and slag safely out of the furnace, except with very hard driving and very fast running in a large furnace.

(5) The heat generated by oxidation at the focus has already been calculated. The proportion to credit to carbon is

$$\frac{668{,}170}{1{,}345{,}990} = 0.496 = 49.6 \text{ per cent.}$$

and to oxidation of sulphides 50.4 " (5)

In the ore smelting these figures were found to be 31 and 69 per cent, respectively.

(6) The ratio of concentration is usually found by comparing the per cent of copper in the material treated with that in the material produced. This would give in this case:

$$\frac{49.63}{20.00} = 2.48 \quad (6)$$

A more reasonable factor, however, is the ratio of weight of

fresh copper-bearing materials treated to weight of copper-bearing materials produced which must be further treated. This would be in this case:

$$\frac{1203}{414} = 2.9$$

whereas in the ore smelting it was

$$\frac{1080}{148} = 7.3$$

"BLISTER-ROASTING" OR ROASTING-SMELTING.

When a matte has been concentrated to somewhere between 70 and 80 per cent of copper it is called "white metal," and is in shape for reduction to metallic copper:

	Cu^2S.	FeS.
With 70 per cent. copper, matte contains	87.5	12.5
With 80 per cent. copper, matte contains	100.0	0.0

The problem being to get metallic copper, the operation is entirely one of oxidation; first, slow melting down of the lumps of matte in a highly oxidizing atmosphere on the hearth of a reverberatory furnace; second, continued oxidation until all the sulphur is removed and the bath remains as metallic copper, saturated with Cu^2O and Cu^2S.

During the melting down the matte is oxidized superficially to such an extent that when fusion is finally complete the copper oxides have reacted upon the iron sulphides sufficiently to eliminate all the iron from the matte. The reactions and phenomena of this period are exactly those of the matte concentration processes.

After the melting down sulphur continues to be oxidized with formation of copper oxide, and then this latter reacts with more of the sulphide to set free metallic copper.

(a) $2Cu^2S + 3O^2 = 2Cu^2O + 2SO^2$.

(b) $Cu^2S + 2Cu^2O = 6Cu + SO^2$.

(c) $Cu^2S + O^2 = Cu + SO^2$.

Reactions (a) and (b) are probably consecutive, but assuming them simultaneous we have equation (c).

Thermochemically, equation (a) analyses as follows:

$2(Cu^2, S)$	= 2(20,300)	= 40,600 Calories	*absorbed.*
$2(Cu^2, O)$	= 2(43,800)	= 87,600 "	*evolved.*
$2(S, O^2)$	= 2(69,260)	= 138,520 "	"
	Algebraic sum	= 185,520 "	"
Per kilo. of Cu^2S		= 583 "	

Similarly, equation (b):

(Cu^2, S)		= 40,600 Calories	*absorbed.*
$2(Cu^2, O)$	= 2(43,800)	= 87,600 "	"
(S, O^2)		= 138,520 "	*evolved.*
	Algebraic sum	= 10,320 "	"
Per kilo. of Cu^2S		= 65 "	"

Equation (c) gives:

(Cu^2, S)		= 40,600 Calories	*absorbed*
(S, O^2)		= 138,520 "	*evolved*
	Algebraic sum	= 97,920 "	"
Per kilo. of Cu^2S		= 615 "	"
Per kilo. of copper liberated		= 770 "	"

The net result of these figures is to show that the first reaction evolves a large amount of heat, that the second is thermally about neutral, and that the two together constitute a highly exo-thermic reaction. When we reflect that a kilogram of melted Cu^2S only carries some 250 Calories, and a kilogram of melted copper not over 200 at any furnace temperature, the large excess of heat above calculated shows up very strikingly.

In a reverberatory furnace the rate of oxidation is so slow that but minor advantage is taken of the heat of oxidation of the Cu^2S.

Illustration: In a reverberatory furnace, 8 tons of "white metal" is smelted to blister copper in 48 hours, using 5 tons of coal. About what proportion does the heat of oxidation of the charge bear to the heat of combustion of the coal?

Assuming the tons to be 1,000 kilos., the white metal to be nearly pure Cu^2S, and the calorific power of the coal 6,000, we have:

Heat of oxidation of the bath	8000 × 615	= 4,920,000 Calories
" of combustion of coal	5000 × 6000	= 30,000,000 "
" requirement for 48 hours		34,920,000 "
" requirement per hour		727,500 "

Proportion of heat requirement furnished by oxidation of both:

$$\frac{4,920,000}{34,920,000} = 0.141 = 14.1 \text{ per cent}$$

The above figures teach us, however, that when the charge is once melted, that if the oxidation of the bath could be performed quickly enough it alone would keep the furnace up to heat. For example, the furnace requires an average of 727,500 Cal. per hour to keep it up to heat. The heat of oxidation would therefore supply this for

$$\frac{4,920,000}{727,500} = 6\tfrac{3}{4} \text{ hours},$$

which means that if the bath, when melted, could be oxidized in that time all exterior firing would be unnecessary after the charge had been once melted. Some companies force air onto the surface of the bath, and one company blows compressed air through wrought iron pipes into the bath, producing the required oxidation in one-fifth the time usually required, and saving greatly in coal.

Bessemerizing Copper Matte.

John Hollway, in 1878, patented the process of oxidizing matte to metallic copper in an apparatus similar to the Bessemer steel converter; in 1880, Manhès, in France, was successful in accomplishing this result, and in 1884 ran the first commercial plant at the Parrot works in Butte. While the principles are similar the details are very different from the blowing of pig iron to steel.

In oxidizing pig iron the carbon, silicon, manganese, etc., which are to be oxidized out rarely exceed 10 per cent, while the iron itself is oxidizable, and some 3 to 20 per cent may be lost. In oxidizing matte some 40 to 70 per cent of the whole charge is to be oxidized, a very voluminous slag results, and the operation lasts five to fifteen times as long. Towards the end of a "steel" blow, the pure iron formed is itself oxidizable, and is not chilled but really heated by the passing of the blast through it; in a "matte" blow the pure copper separating at the end is not oxidizable under the prevailing conditions, and therefore is only chilled by the blast if the latter strikes it. On the latter account, tuyeres in the bottom are impracticable when Bessemerizing matte, since they become filled with chilled copper. It is imperative to use lateral tuyeres which, by the swinging of the converter, are kept always below the surface of the matte but above the pool of copper as it separates out and sinks to the bottom.

The two best treatises for details of bessemerizing copper matte are Jannettaz "Les Convertisseurs pour le Cuivre" and Dr F. Mayr's "Das Bessemern von Kupferstein", very satisfactory information can be found in Dr. Peter's "Modern Copper Smelting" and "Principles of Copper Smelting," in Hixon's "Notes on Lead and Copper Smelting and Copper Converting" and in Schnabel's "Handbook of Metallurgy." Last edition Vol. I.

Assume that a converter is just emptied, is at a bright red heat (1,100°), and that a charge of melted matte at, say, 1,100°

(setting point 1,000°), is poured into it. The lining is some 60 c m thick, the outside shell of the converter is at about 200° C., and the surface is losing heat at a nearly steady rate of, say, 50 Cal. per square meter of outside surface per minute (10-pound Cal. per square foot). A converter of 25 square meters outside surface would thus lose 1,250 Cal. per minute if standing still. If it had 3,000 kg. of liquid matte in it, with a specific heat of 0.14, the latter would give out 3,000 × 0.14 = 420 Calories for every degree which it cooled, and would therefore cool off about 1,250 ÷ 420 = 3° per minute. If poured in 100° above its setting point it might be some 30 minutes in cooling to its setting point and 70 minutes in setting, assuming no radiation losses through the throat, i. e., that the throat were tightly covered.

Under such conditions, if blast is turned on, the reaction is

$$2FeS + 3O^2 + 2SiO^2(\text{lining}) = 2(FeO, SiO^2) + 2SO^2$$

and the heat evolved is

Decomposition of	2FeS = 2(24,000)	= −	48,000 Calories.
Formation of	2FeO = 2(65,700)	= +	131,400 "
Union of 2FeO with	$2SiO^2$ = 2(8,900)	= +	17,800 "
Formation of	$2SO^2$ = 2(69,260)	= +	138,520 "
	Total	= +	238,720 "
Heat evolution per 1 kg. FeS		=	1,356 "
Heat evolution per 1 kg. O^2		=	2,487 "

Theoretical Temperature Rise.

Supposing we oxidize an amount of FeS equal to 1 per cent of the weight of matte. Let us calculate the theoretical rise in temperature of the contents of the converter.

The oxygen required is $3O^2$ to 2FeS, or per kilo. of FeS.

Oxygen required	= 96 ÷ 176 = 0.545 kg.
N^2 accompanying	= 1.818 "
Air required	= 2.363 "
Volume	= 1.827 m³.

In being raised from say 50° C. to 1100°, the assumed temperature of the matte, the air will absorb

$$1.827[0.303 + 0.000027(1150)] \times 1050 = 641 \text{ Calories.}$$

This leaves available, for raising the temperature of the products of the reaction:

$$1,356 - 641 = 715 \text{ Calories.}$$

The immediate products are:

99.	kg. of unoxidized matte.
1.50	" " liquid slag.
0.73	" " SO^2 gas.
1.82	" " N^2 gas.

The heat capacities of these, at 1100°, is as follows, per 1° C.:

Matte	99 × 0.14 = 13.86 Calories.	
Slag	1.50 × 0.27 = 0.41	"
SO^2	0.73 × 2.88 × 1.02 = 0.25	"
N^2	1.818 × 1.26 × 0.36 = 0.52	"
	Sum = 15.04	"

Theoretical temperature rise

$$715 \div 15.04 = 47.5° \text{ C.}$$

The above rise represents the *rate* at which the temperature tends to rise at the beginning of the blow. Supposing this amount of FeS (1 per cent) is oxidized in 1 minute, the temperature at the end of 1 minute would rise 47.5° less the cooling off in 1 minute, which latter might be from 2° to 10°, according to the size of the converter and its charge, thickness of lining, etc. For practical purposes the cooling-off rate may be assumed as nearly constant, but the heating-up rate is very variable. As the FeS disappears the amount of slag increases, while that of the matte decreases; but since 1.50 kilos. of slag with a calorific capacity of 0.41 Cal. per degree takes the place of 1 kilo. of matte with a calorific capacity of 0.14 Cal. per 1°, the heat capacity of the products is increasing 0.27 Cal. for each 1 per cent of FeS oxidized, while the available heat for raising temperature is slightly decreasing, because of the higher temperature of the bath and therefore the greater chilling effect of the air. Assuming that the bath cools 5° during the time that 1 per cent of FeS is being oxidized out, we can calculate the following table:

FeS Oxidized.	*Temp. at Start.*	*Heat Absorbed by Air.*	*Net Heat Available.*	*Calorific Capacity of Products.*	*Temp. Rise.*
0 to 1%	1100°	641	715	15.04	42.5°
1 " 2%	1142.5°	670	686	15.31	40°
2 " 3%	1182°	694	662	15.58	37°
3 " 4%	1219°	722	634	15.85	35°
4 " 5%	1254°	742	614	16.12	33°
5 " 6%	1287°	768	588	16.39	31°
6 " 7%	1318°	789	567	16.66	29°
7 " 8%	1347°	809	547	16.93	27°
8 " 9%	1374°	823	533	17.20	26°
9 " 10%	1405°	847	509	17.47	24°
At 10%	1429°	...	...	.....	....

There is no object in extending above table, because it is constructed on the particular assumption that radiation losses would amount to 5° during the burning out of 1 per cent of FeS. This quantity would evidently vary with the size of the converter, the amount of matte being treated and the speed of blowing, because as the contents become hotter their rate of cooling would be increased. The object of the above table, so far as it went, was to show that 47.5° was the theoretical rise for the first 1 per cent, but that the theoretical rises for succeeding percents would be less and less; in such manner, instead of rising (47.5 − 5) × 10 = 425° for an oxidation of 10 per cent of FeS the actual rise figures out only 329°.

One of the most necessary data which is badly needed for these converters, and in fact for Bessemer converters in general, is the heat loss by radiation and conduction, in other words, how much heat would be lost by the charge if simply standing still, how much would the temperature of a given charge fall per minute if standing still? This could be easily obtained by running in a charge of pretty hot matte, and following its temperature curve as it cools, without any necessity of letting it freeze, but merely starting up the blast when the rate of cooling had been satisfactorily determined. If these determinations were coupled with details as to the temperature of the outside air, its velocity of impingement against the converter, the temperature of the outside shell, the area of radiating surface and the thickness of the lining, we would soon get data with which to render entirely definite and exact the whole thermal investigation of a "Bessemerizing" operation. This should be supplemented by analyses of the gases during the blow and the temperature curve of the contents as the blow progresses. Scientific metallurgists must, at present, simply assume many of these data, because of lack of them. We are looking to the metallurgical directors of copper plants for some of this badly-needed technical data.

Problem 110.

W. Randolph Van Liew (*Trans. Am. Inst. Mining Eng.*, 1904, p. 418) gives the following analyses of a charge of matte blown to blister copper in a Bessemer converter:

	Cu.	*Fe.*	*S.*	*Zn.*
Matte	40.72	23.31	21.28	1.19
10 minutes	50.20	23.15	20.95	1.20
20 "	56.88	17.85	19.74	0.84
30 "	64.60	10.50	18.83	0.70
40 " (last slag skimmed)	76.37	2.40	16.30	0.45
70 " (blister copper).	99.120	0.038	0.159	0.09
	As.	*Sb.*	*Ag.*	*Au.*
Matte	0.11	0.14	0.152	0.00055
10 minutes	0.09	0.12	0.147	0.00048
20 "	0.08	0.10	0.176	0.00069
30 "	0.08	0.13	0.191	0.00083
40 " (last slag skimmed)	0.08	0.13	0.240	0.00110
70 " (blister copper).	0.0012	0.006	0.312	0.00111

The percentage composition does not exhibit clearly the relative time and amount of the elimination of impurities, because of the varying weight of the bath.

Required:

(1) Assuming 1,000 kilograms of matte to be treated, find the weight at each period of the blow of the matte.

(2) The loss of each constituent of the bath during each period.

(3) The heat evolution during each period.

(4) The loss of heat per minute due to radiation and conduction, assuming that the heat starts with matte at 1,100° and ends with blister copper at 1,200°, and that 1 per cent of copper (reckoned on the matte) is oxidized during the last period.

(1) The first question is to find some constituent of the matte, whose weight does not vary during the blow, to serve as a basis for the calculations. If the analyses be taken as reliable in all details (we can make no other assumption) we see that there is very little loss of anything in the first 10 minutes, evidently because of the low temperature of the matte. Afterwards, iron falls off rapidly, also sulphur and zinc, while silver and gold increase in percentage, because of the falling off in weight of the bath as a whole. The slag, up to the last skimming, contains usually but very little copper; in the last period we are told to assume a loss of 10 kilos. of copper by oxidation. The most rational basis for calculating the weight of the bath is to assume the copper contents constant for the first 40 minutes.

Copper in 1000 kg. of matte at starting 497.2 kg.

Weight of matte at starting			1000.0	"
" " "	10 minutes	= 497.2 ÷ 0.5020 =	990.4	"
" " "	20 "	= 497.2 ÷ 0.5688 =	874.1	"
" " "	30 "	= 497.2 ÷ 0.6460 =	769.7	"
" " "	40 "	= 497.2 ÷ 0.7637 =	651.0	"
" " metal	70 "	= 487.2 ÷ 0.0912 =	491.5	" (1)

From the analyses given, and calling the shortage of percentage in the analyses oxygen, we have the following table of weights and eliminations: (2)

Per 1000 kg. of Original Matte.

	Cu.	*Fe.*	*S.*	*O.*
Start.....	497.2	233.1	212.8	41.0
Eliminated...	0.0	3.8	5.3	0.1
End 10'.....	497.2	229.3	207.5	40.9
Eliminated...	0.0	73.3	35.0	2.9
End 20'.....	497.2	156.0	172.5	38.0
Eliminated...	0.0	75.2	27.6	0.3
End 30'.....	497.2	80.8	144.9	38.3
Eliminated...	0.0	65.2	38.8	12.0
End 40'.....	497.2	15.6	106.1	26.3
Eliminated...	10.0	15.4	105.3	24.9
End 70'.....	487.2	0.2	0.8	1.4

Zn.	*As.*	*Sb.*	*Ag.*	*Au*	
11.9	1.1	1.4	1.52	0.0055	1000.0
0.0	0.2	0.2	0.06	0.0007	9.6
11.9	0.9	1.2	1.46	0.0048	990.4
4.6	0.2	0.3	0.08	0.0012	116.3
7.3	0.7	0.9	1.54	0.0036	874.1
1.9	0.1	0.1	0.07	0.0004	104.4
5.4	0.6	1.0	1.47	0.0064	769.7
2.5	0.1	0.2	0.09	0.0008	118.7
2.9	0.5	0.8	1.56	0.0072	651.0
2.5	0.5	0.8	0.03	0.0017	159.5
0.4	0.0	0.0	1.53	0.0055	491.5

Our table is not absolutely accurate, as can be seen from an apparent gain in both silver and gold in the periods 10 — 20 and 30′ — 40′. This is caused by a loss of copper during those periods, but the amounts of gold and silver are too small to serve as a base for revising the table. If we were to assume the gold as constant it would make a smaller weight of bath at the ends of those periods, but the figures are not reliable enough to make this correction worth while.

The very small total loss in the first 10 minutes and the loss of time thus occasioned could in all probability be obviated by putting the matte hotter into the converter at the start.

A graphic representation of the course of a blow is usually made by plotting the *percentages* of each element in the bath at given periods. *This plan is largely misleading*, the diagram should be made by plotting the calculated *weights* of each element present at the given periods, such as are found in the above table.

(3) The heat evolution is to be found by taking the weights of each element oxidized out, calculating the heat of its oxidation and formation of slag, and subtracting the heat necessary to break up the equivalent amount of its sulphide. The heat necessary to separate the sulphides from each other is unknown.

Period I.—Start to 10′.

		Cal.	*Cal.*
Heat of oxidation			
Fe to $FeO.SiO^2$	3.8×1332	= 5,062	
S " SO^2	5.3×2164	= 11,469	
As " As^2O^3	0.2×1043	= 209	
Sb " Sb^2O^3	0.2×695	= 139	
			16,879
Decomposition of sulphides.			
Fe from FeS	3.8×429	= 1630	
As " As^2S^3	0.2×2000 (?)	= 400	
Sb " Sb^2S^3	0.2×1433	= 287	
			2,317
Net heat evolution			14,562

The other periods are similarly calculated, and yield the following results:

	Start–10′	*10′–20′*	*20′–30′*	*30′–40′*	*40′–70′*	*⅓ last.*
Heat of oxidation..	16,879	179,797	162,476	174,316	257,046	85,682
Decomp. of sulphides	2,317	35,321	33,719	30,113	10,410	3,470
Net heat evolution	14,562	144,476	128,757	144,203	246,636	82,212

The last column is added for comparison, being the heat evolution per average 10′ in the last period. (3)

(4) The loss of heat by radiation and conduction can be found, as a whole, by assuming the converter body to contain the same heat at finishing as at starting, which is a likely assumption, since the lining loses somewhat in weight but ends up at a higher temperature. Then we know how much heat was in the original matte at 1,100°, how much was generated, how much is in the slag and copper, and can calculate approximately how much is carried out in the gases. These enable us to find, by difference, the loss by radiation and conduction which can then be averaged up per minute.

	Calories
Heat in 1000 of matte at 1100°	= 214,000
Net heat generated in the blow	= 678,635
Total available	= 892,635
Heat in 491.5 Copper, at 1200°	= 85,095
" " 424 SO^2, " 1000°	= 97,020
" " 0.17 N^2, " 1000°	= 248,160
" " 1000 Slag, " 1250°	= 187,000
Heat accounted for	618,175
Loss by radiation and conduction	= 274,460
Loss per minute, per 1000 kg. matte	= 3,920 (4)

It is thought that the principles explained and the methods of calculation illustrated will suffice to show to copper metal-

lurgists how important information is obtainable by applying the principles of thermo-chemistry to copper smelting, and to indicate the lines along which experiment and results of measurement and observation are greatly to be desired.

[The next instalment of these calculations will be concerned with the electrometallurgy of copper.]

Electrothermic Combustion of Atmospheric Nitrogen.

A very interesting paper on the fixation of atmospheric nitrogen was recently presented before the Manchester Section of the Society of Chemical Industry by Mr. F. Howles, who was one of the earliest workers in the field, and made in 1898-9, together with Mr. McDougall, a valuable investigation of the principles of the combination between oxygen and nitrogen in air under the influence of electric discharges.

Mr. Howles agrees with the theory now generally accepted that the oxidation of nitrogen in the arc is a purely thermal phenomenon. With increasing temperature part of the oxygen and nitrogen in the air will combine, and for every temperature when equilibrium is reached there is a definite volume of concentration of the oxide in the gas mixture which has been determined by Nernst. The higher the temperature the higher the concentration of nitric oxide.

The ordinary high-tension arc in air consists of three superimposed zones, all mounting upwards and of different size and temperature. Zone 1, the lowest zone, carries the major portion of the current, and therefore has the highest temperature, about 4,200° C. It is probable that in this zone alone the oxidation of nitrogen takes place. Zone 2, or the middle zone, is greenish-blue in color with a temperature of at least 1,400° C. Zone 3, or the highest zone, forms the greatest bulk of the flame. It is of a pale yellowish-brown color, and its temperature is 900° to 100°, according to Muthmann and Hofer, though Mr. Howles thinks this figure is too low.

While in zone 1 the nitric oxide is formed, the reverse happens in zones 2 and 3. When the gas mixture containing the nitric oxide is removed from the zone 1, and passes through zones 2 and 3, the nitric oxide is dissociated and part of the useful work performed in zone 1 is undone.

The first condition of getting a high yield is to get as high a temperature of the arc as possible in zone 1. The second is to remove the gas mixture from the sphere of influence of the arc as quickly as possible after the reaction has taken place in order to prevent the dissociation in the cooler parts of the arc. Quite intimately connected with this second condition is Mr. Howles' third condition, namely, the necessity of reducing by some means the relative values of zones 2 and 3 of the flame, in which dissociation of nitric oxide takes place, and at the same time to increase the capacity of the first zone in which the nitric oxide is produced.

A fourth important consideration in the technical production of nitric oxide is the concentration of large amounts of energy in a unit of plant. With the ordinary high-tension flame it is not possible or at least not advisable to use currents of more than 0.1 to 0.2 amp.; for as the researches of Mr. McDougall and Howles have shown, a diminished yield of nitric oxide results. But as the yield of oxide is a function of the energy consumed, since the reaction $N_2 + O_2 = 2NO$ requires an expenditure of 43,200 cals., a plant constructed for the utilization of a large number of low-current arcs would entail the erection of an enormous number of units, if any large quantity of acid had to be produced. The up-keep and labor charges on such a plant would necessarily be high, and to this fact is attributable the failure of the earlier processes.

Mr. Howles gave a brief review of various technical processes which have been proposed or used for the fixation of atmospheric nitrogen. "The process proposed by Mr. McDougall, which yielded about 300 kilos. of nitric acid per kilowatt-year is now only of historic interest, as is also that of Bradley and Lovejoy, since both processes suffer from the inherent defects mentioned above."

Mr. Howles then refers to the process of J. de Kowalski and M. Moscicki, which was described and illustrated in our Vol. II., p. 152. He comments on this process as follows: Whether a current of high periodicity and voltage, such as the one used by them, possesses some special advantage or whether the increased yield is merely the result of some mechanical property of an arc so produced, does not appear to be clear from the experiments of these authors. The latter view is probable, since the yield of nitric acid obtained by Kowalski and Moscicki has been far surpassed by subsequent workers, who used currents of only moderate periodicity and voltage. This process also, if worked commercially, would require a large number of units of plant, since only 2½ kilowatts are condensed in each arc.

Mr. Howles then passes over to the discussion of the well-known process of Birkeland and Eyde, which has been described in detail and with illustrations repeatedly in our former volumes. Concerning prior work along the same lines the following notes are given: "Plücker (*Poggendorf's Annalen*, Vol. 133, p. 252), in 1861, had shown that when a high-tension discharge passed between electrodes, situated in a magnetic field and at right angles to the magnetic lines of force, a disc of sparks resulted, and that when the phenomenon occurred in a vessel filled with air, the formation of brown oxides of nitrogen was observed. Lehmann (*Die elektrischen Lichterscheinungen und Entladungen*, 1898, p. 353), in 1898, applied this arrangement to the high-tension electric flame, and obtained a similar spreading of the arc. When a direct current is used, the arc resembles a half circle; with an alternating current an approximately circular disc is formed."

After having described the industrial development of the Birkeland-Eyde process in Norway, Mr. Howles discusses some investigations of the Badische Anilin und Soda Fabrik. When using alternating currents for the production of the electric flame it is necessary to introduce, in series with the arc, an inductance, which effects a displacement of phase, thus regulating the current and enabling the flame to burn steadily. A transformer constitutes such an inductance, the iron cores of which, when the current is passing, are converted into magnets. In a patent taken out in 1904 (English patent 5,688), the Badische Anilin und Soda Fabrik claim the use of such a magnetic field for spreading out the arc. They thereby avoid the use of a separate current for exciting the magnets. Of this arrangement other advantages are also enumerated, notably the self-inductive action in the arc, which the cyclical motion imparted by the alternating current to the magnetic field produces, whereby the inner resistance, and consequently the stability of the arc, is increased.

This particular combination of apparatus, however, does not appear to have been technically applied, as in 1906 the same company make use of another method of producing arcs of great power (English patent 9,279, of 1906). The arrangement consists essentially of an iron tube, 1 meter or more in length, at one end of which an insulated electrode is situated, a single electrode electrically connected to the tube being inserted at the opposite end. On passing a current of some few thousand volts an arc is established between the insulated electrode and the wall of the iron tube adjacent to it. If, now, air, with a whirling motion be blown into the tube, the arc travels along the wall to the opposite electrode, and as long as the current of air is maintained the arc continues to burn steadily between the electrodes. Several insulated electrodes are also used, each in separate tubes, the latter, however, all leading into a common chamber, in which is situated the electrode electrically connected with the tube. It is, moreover, found that, by the use of either single-phase or polyphase currents, several arcs in one tube can be obtained burning quietly side by side and uniting at the upper end of the tube, which is

earthed so that no danger is incurred by touching it; 100 kilowatts of electrical energy have been employed in each arc. This apparatus is extremely simple, and should good yields of acid be obtained there appears to be no reason why the process should not be a commercial success.

Of other methods of burning atmospheric nitrogen it will be interesting to notice those of Naville and Guye (French patent 361,827 of 1905), and of Pauling (French patents 368,715 and 368,717 of 1906), who appears to be working in conjunction with the Salpetersäure Industrie Gesellschaft. The former workers, by rotating a disc-shaped electrode E—situated in a cylinder of refractory material C—over a metal tube A, conveying the air to be treated, and which forms the second electrode, obtained a spreading of the arc round the periphery of both the tube and the disc. By this method a yield of 400 kilos. of nitric acid per kilowatt-year has been obtained.

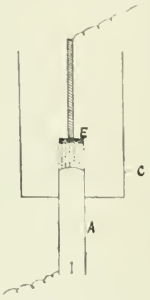
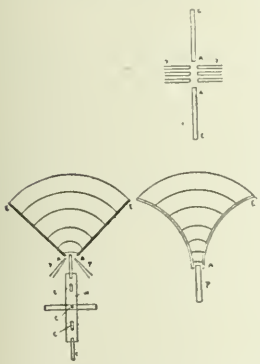


FIG. 1.—APPARATUS OF NAVILLE AND GUYE.

The apparatus devised by Pauling consists of either straight or curved fixed electrodes A E inclined to one another in a vertical plane. At regular intervals solid conductors C, which are fixed on the periphery of a revolving wheel W, pass between the lower ends of the electrodes, thus causing an arc to spring across. By means of an air blast, conveyed by pipes P, the arc, continually increasing in size, is made to travel upwards along the electrodes, until the points E are reached, when it becomes extinguished. As each solid conductor passes the electrodes a new arc is formed, which in its turn goes through the same process. In another method the wheel carrying the solid conductors is not used. Opposed tuyeres, conveying an air blast, cause the arcs, which are continually produced at A, to lengthen and break at E, as described in the previous process.


FIGS. 2 AND 3.—APPARATUS OF PAULING.

Pauling has also endeavored to oxidize nitrogen without the intervention of electrical energy (English patent 21,828 of 1902). By passing a mixture of air and steam through thin-walled porcelain tubes heated to incandescense he observed the formation of nitric oxide and hydrogen. The latter gas diffused through the walls of the tubes, and this diffussion was increased, either by means of a pressure inside the tubes or a partial vacuum outside. Later, the gases issuing from the incandescent porcelain tubes were rapidly lowered in temperature by the injection of cold air (English patent 7,870 of 1906), thus minimizing the action due to the phenomenon of reversibility.

Häusser (English patent 12,401 of 1906) also avoids the use of the electric flame in the combustion of nitrogen. He reverts to the explosion method of oxidation, the feasibility of which was first demonstrated by Bunsen and Kolbe in 1846. The special apparatus used by Häusser consists of a gas engine, in which the usual mixture of air and gas is exploded. The products of combustion are, however, rapidly cooled by the injection of cold water into the combustion chamber. As with the process last described there appears to be no published data relating to the yield of acid thus obtained.

In discussing the results obtained, Mr. Howles states that the yield of 950 kg. of nitric acid per kilowatt-year represents the greatest output so far realized. Assuming a mean flame temperature of 3,200° C., this represents an efficiency of 79.3 per cent of that theoretically possible.

The relative reduction in volume of zones 2 and 3 of the flame, which is so essential to successful working, would appear to have been partially realized in the Birkeland Eyde furnace. The spreading of the "current paths" by magnetic force should tend to equalize the temperature of the flame, and prevent that great opportunity for gradual temperature fall which is observed in the ordinary high-tension flame, and which is so inimical to the attainment of a satisfactory yield.

Against the advantage, however, must be placed the energy required to maintain the magnetic field, amounting as it does to 10 per cent of the quantity consumed in the arc and which is not included in calculating the yield of acid. The temperature of the flame might be raised by increasing the resistance of the gases, by working under pressures above that of the atmosphere.

It is interesting in this connection to note some experiments of Muthmann and Hofer (Berichte, Vol. XXXVI., 1903), who found that by increasing the pressure of the gases surrounding the arc from 1 to 1.4 atmospheres, the velocity of the air passing into the arc chamber could be accelerated, and although the exit gases contained the same percentage of nitric oxide, yet the yield was increased threefold per unit of energy consumed. Such a result could only be due to increased flame temperature, caused by the added resistance of the air to the passage of the current consequent upon increased pressure.

These experiments are important, containing, as they do, two elements of success, *i. e.*, an increase in flame temperature and a more rapid removal of the nitric oxide from the arc, due to the greater air velocity, and this without increased dilution. An extension of this work would probably yield interesting results.

Against the increased yield, however, must be set the cost of compressing the gases and the difficulties which always obtain in practice in working at high temperatures under pressure.

Absorption of Nitric Oxide and the Preparation of Nitric Acid.

After leaving the furnace, the air contains about 2 per cent by volume of nitric oxide, which becomes rapidly converted, by means of the excess oxygen present, into nitrogen peroxide. The mixed gases then pass on to absorption towers, which present no special features of construction and down which water or dilute acid flows. In the case of the last tower, milk of lime is used, as it is difficult to absorb the last traces of NO_2 by means of water alone. By this process one obtains an acid of not more than 50 per cent strength.

The preparation of a concentrated nitrous-free acid from the nitrous gases constitute one of the most serious problems in connection with this process. The reaction represented by the equation:

$$2NO_2 + O + H_2O = 2HNO_3,$$

does not take place in the absorption towers, such an equilibrium appears to exist only in the gaseous state. On condensation the right-hand side of the equation is not produced. The most concentrated acid which has so far been obtained by the condensation of nitrous gases in water in the presence of oxygen corresponds to the formula HNO_3, $2H_2O$, and possesses a density of 40.6 B., representing 63.63 per cent of anhydrous nitric acid. The formation of this acid takes place, according to the following equation, in the Lunge and Rohrmann plate towers:

$$2NO_2 + O + 5H_2O = 2(HNO_3, 2H_2O),$$

from which acid of 40° to 41° B. is obtained. By passing the gases, however, through towers down which water flows, an equimolecular mixture of nitric and nitrous acids results,

which, at the most, cannot attain a concentration greater than that obtained in the Lunge towers. Attempts at further concentration, by the passage of nitrogen peroxide through the solution, simply result in an increase of nitric acid at the expense of the nitrous. The strongest acid is thus never free from nitrous acid, and each succeeding absorption tower contains less and less nitric acid, whilst at the same time the nitrous acid increases, for as the free oxygen in the gases becomes consumed the NO and NO_2 tend to react as N_2O_3, yielding only nitrous acid. It is not possible to prepare much stronger acid by fractionating the 50 per cent acid from the first absorption tower, since a product of minimum vapor pressure, boiling at 120°, and containing 68 per cent of anhydrous acid, is obtained as residue.

Thus in order to prepare the most concentrated acid by the nitrogen combustion process it would be necessary to either add the 50 per cent acid to concentrated sulphuric acid until a dilution of say, 54° B., be obtained (54° B. = 120° Tw = 68.5 per cent of H_2SO_4), and distill off the nitric acid; or to prepare a salt of nitric acid, and distill in the usual way with sulphuric acid or a bisulphate.

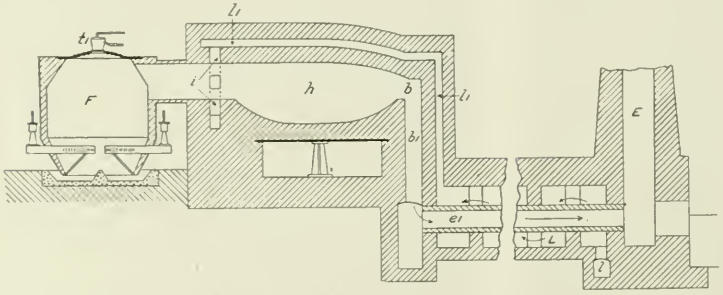
An electrolytic method for concentrating and oxidizing the weak tower acid has lately been patented (French patent 368,716 of 1906). The process consists in refrigerating the oxides of nitrogen evolved during electrolysis at the cathode, and leading them in the liquid state slowly to the anode compartment of the cell, where in presence of the nascent oxygen there generated a solution of pure nitric acid results, all nitrous acid undergoing oxidation. It is not stated if this process has proved a commercial success.

Thus, although the electrochemical production of nitric acid has attained a fair degree of efficiency in some of the processes touched upon, the problem of directly manufacturing from the furnace gases a 98 per cent acid has not yet been solved.

The Use of Producer Gas In the Chemical Industries.

By Oskar Nagel, Ph. D.

In Germany great progress has been made lately in the application of producer gas for melting, calcining roasting, heating with reducing or oxidizing flame and evaporating. A large number of sulphate furnaces are now operating with producer gas and the total saving of labor and fuel in most of them amounts up to 50 per cent. The general advantages of producer firing are:



NO. 1.—REVERBERATORY FURNACE FIRED WITH PRODUCER GAS.

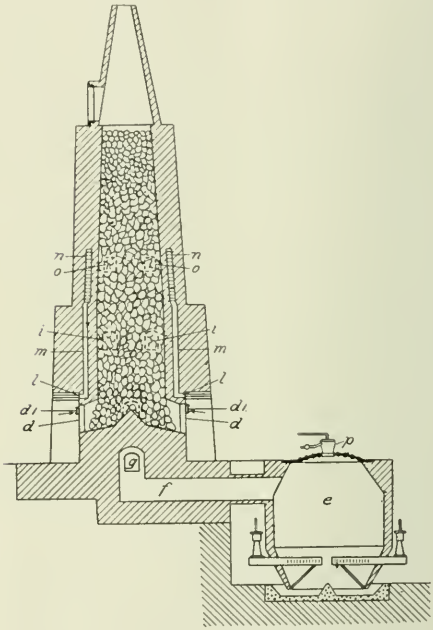
a. By regulating the quantity of gas and air conveyed to the place of combustion a perfect and uniform combustion is obtained.

b. According to requirements an oxidizing or reducing flame can be obtained, which is of importance to the chemical and metallurgical industries.

c. The process of combustion can be limited to a small place, whereby the effect to be attained is frequently reached better and quicker than with direct firing.

d. It is possible in every case to utilize perfectly the waste heat by preheating the combustion air or the gas.

e. The material to be burned or worked does not come in



NO. 2.—LIME KILN FIRED WITH PRODUCER GAS.

contact with the solid fuel or ashes, which is of importance for the manufacture of lime and of clay products.

f. The attendance is easier, is simpler and cheaper than with direct firing.

g. The places of the gas production and gas consumption can be separated; thence one producer or a battery of producers can furnish fuel to a large number of furnaces. A long distance of producer and furnace is rather an advantage, as it causes the complete condensation of steam in the producer gas.

The special advantages of importance to sulphate works and other chemical factories are:

a. The possibility of burning low-grade fuel.

b. Production of a uniform product on account of the regulability of the temperature.

Producer Gas-Fired Reverberatory Furnace.

The principal outlines of a gas-fired reverberatory furnace are shown in Fig. 1. The change from direct fire to gas fire consists mainly in the addition of the gas producer and recuperator between furnace and chimney. The recuperator consists mainly of a system of fire-clay pipes (e1) which connect the flue b with the chimney F. This pipe system is built into a wider channel L in which the air required for the combustion of the producer gas is introduced at l. The air goes in chan-

nel L around the pipe system, as shown in the cut by arrows, absorbs the heat of the escaping fire gases and carries this heat back to the furnace through the channels and openings i. These channels are connected with the hot air chamber L of the recuperator by air slits or air channels l'. In these air slits which are arranged throughout the width of the furnace arch the air is brought to a still higher temperature. Thence at the fire bridge incandescent producer gas is mixed with incandescent air, causing a perfect combustion. In working with a reducing flame the combustion is nearly smokeless. It gets perfectly smokeless by the use of a slight excess of air. The saving is effected by the higher temperature obtained, by the recovery of the heat in the recuperator, by reducing the radiation of the fire-place, by the exact regulability of the firing, by the perfect combustion and by the longer life of the fire-brick.

Lime Kilns.

As lime is largely used in the chemical industries a description of a producer-fired gas lime kiln, as shown in Fig. 2, will be of interest.

The gas generated in the producer goes through sewer f to the gas distributing flue g, from which the gas passes through vertical channels to the gas inlet openings i. Being under pressure the gas is equally distributed over the entire area. The combustion air enters at d', absorbs the heat stored in the lower part of the shaft and is highly preheated while the burned material in the furnace is cooled at the same time. The air arrives (on account of the high temperature) at the place of combustion at a certain pressure, which prevents the drawing in of excess air and effects the uniform distribution of the air as well as of the gas. The combustion of the producer gas by the hot air is taking place between and above the gas inlets. That part of the producer gas which rises upward immediately at the inlet openings does not meet the amount of air necessary for combustion, which, however, is introduced above the gas inlet through the air inlets o. This "second" combustion air enters the shaft at l, rises through m, is distributed in the channels m n behind the fire-brick lining of the combustion zone proper and finally enters the shaft through openings c. By means of this arrangement the fire-brick lining is air cooled from the outside and the rising producer gas completely burned by the second combustion air.

It is evident that with such a producer-gas installation a uniform heat is obtained, that the utilization of the heat is far superior to direct fire, and that a great saving in the fuel consumption (25 to 50 per cent) is effected. Further advantages are the production of pure material and longer life of the shaft.

A producer especially adapted for this kind of work is the Herrick producer, which is manufactured by the Industrial Gas Co., of New York. It is shown in the cuts connected to a reverberatory furnace and lime kiln. It is of the water seal type, and the special construction of its tuyeres insures the uniform distribution of the blast, thereby effecting the formation of gas of constant composition.

The way of mixing the gas and the air is of fundamental importance for getting a complete and smokeless combustion. In a wide hearth the gas will advantageously be introduced in a number of parallel currents. In this case the air has to be applied analogously, so that there is one gas channel corresponding to every air channel. As the air is heavier than the gas, it is by no means immaterial whether the air channels are constructed above or below the gas channels. If the air is introduced above the gas a quicker combustion is obtained; reduction processes are conveniently performed with "upper" air. If the air is introduced below the gas a slower combustion i. e. a longer flame, is obtained; oxidation processes are conveniently performed with "lower" air. While parallel currents of gas and air are used if a large area is to be heated, the gas and air are brought together under an angle for heating a narrow space; for heating a small object gas and air are combined at a right angle.

The Fixation of Nitrogen.*

By Norman Whitehouse.

The object of this research was to obtain a workable commercial process by which the nitrogen of the atmosphere could be obtained combined as ammonia or nitrate, and was undertaken at the suggestion of Sir William Ramsay. It is obvious that if any commercial process is to be worked out using a metallic nitride as the nitrogen carrier, then one of the following methods of treatment must be possible:

1. The nitride chosen must be directly reducible with hydrogen, giving ammonia together with the metal, a lower nitride or a hydride.

2. A nitride when treated with steam will always give ammonia and the oxide of the metal; but if this reaction is used the oxide produced should be one which is conveniently reducible with hydrogen or carbon.

3. If the nitride will react with hydrogen sulphide or hydrogen chloride, this reaction may be employed, provided the sulphide or chloride is reducible.

The reasons for the failure to work out a commercial process on these lines may be summarized as follows:

1. With certain exceptions, such as cerium, metals which combine with atmospheric nitrogen were found not to be directly reducible with hydrogen.

2. The oxide of metals which will react with molecular nitrogen are also non-reducible with hydrogen or carbon at a reasonably low temperature, that is to say, under about 1,500° C., above which temperature the working becomes both difficult and costly.

3. In some cases hydrogen sulphide and hydrogen chloride do not react with the nitrides of those elements which combine directly with nitrogen. But when they do, the resulting compounds are not themselves easily reducible.

The first experiments were carried out with *magnesium* nitride, as it is common knowledge that magnesium, if strongly heated, combines with nitrogen giving this compound. As is well known, it reacts with water with violence, giving rise to ammonia and the hydroxide of the metal

$$Mg_3N_2 + 6HOH = 2NH_3 + 3Mg(OH)_2.$$

It also burns if strongly heated in air, forming oxide and free nitrogen. It was obvious that if any commercial process was to be worked out, using magnesium nitride as the nitrogen carrier, it would be necessary to prevent the magnesium changing to oxide in its cycle of reactions. With this in mind, some experiments were undertaken to find out if it were possible to effect the reduction of magnesium nitride directly with hydrogen at various temperatures between 400° C. and about 1,000° C. An iron tube was used to contain the porcelain boat holding the nitride, and the whole was heated in an electric tube furnace. After repeated experiments it was found that if the hydrogen were freed from every trace of oxygen by passing the gas over red-hot copper, and from moisture by bubbling it through sulphuric acid drying tubes, then no appreciable reduction took place. The difficulty experienced in these experiments of getting rid of every trace of air brought home the unsuitability of magnesium nitride for a commercial process; it was also evident that in any commercial undertaking "water gas" would have to be employed. Now, as hydrogen and carbon monoxide cannot be completely separated from one another by any cheap process, the gas would have to be used as a whole. This was found to be impossible, as the magnesium was oxidized, free carbon, cyanamide and other products being formed.

Attention was then turned to *titanium*, the affinity of which for oxygen is not so pronounced as that of magnesium, while that for nitrogen is at least equally great. Experiments were

* A paper read before the London section of the Society of Chemical Industry, from the Journal of the Society, July 15.

made of two nitrides of this element, namely, titanic nitride, a brown powder (Ti_3N_4, according to Wöhler), and titanium dinitride, TiN_2, an amorphous blue powder. The dinitride was prepared by heating the dioxide in a current of ammonia gas at about 600° C. Titanic nitride is obtained when the metal is heated in nitrogen. It is also, and was, actually obtained for these experiments by the ignition of ammonia-titanium tetrachloride in a stream of ammonia gas.

$$3(TiCl_4NH_3) = Ti_3N_4 + 8NH_4Cl + 4HCl$$

Strong ammonia was added to a concentrated solution of commercial titanous chloride, and the resulting blue-black precipitate was dried and ignited in a current of air, when the dioxide was obtained as a yellowish-white powder. The average amount of titanium dioxide obtained was 51 grms. per pound of the concentrated solution of titanous chloride. The preparation of the ammonium titanium tetrachloride was a somewhat lengthy process. It consisted of heating the dioxide in a current of carbon tetrachloride at about 450° C. A mixture consisting mainly of titanium tetrachloride and carbon tetrachloride was obtained in the cooled receiver, and by fractional distillation the titanium tetrachloride of b. p. 130° C. was separated. Dry ammonia gas was passed into the titanium tetrachloride, and the solid canary yellow double salt was obtained. As before mentioned, this, on ignition, gives titanic nitride.

An analysis was made as follows: 1.647 grms. of titanic nitride was weighed in a porcelain boat. The titanium oxide, estimated by igniting the nitride in air, weighed 1.927 grms., corresponding to 70.2 per cent of titanium in the nitride. As the nitride was prepared from commercial oxide an accurate analysis was impossible, but this percentage agrees fairly well with the 72.0 per cent of titanium in pure Ti_3N_4. A similar analysis was made with the dinitride. The percentage of titanium was found to be 64.2 per cent, as compared with 63.3 per cent required by the formula, TiN_2.

The direct reduction of these nitrides with hydrogen was attempted first in an iron tube, and afterwards in hard glass. The use of the iron tube was given up as, although the nitride in the boat did not lose weight, enough ammonia was formed to turn litmus paper blue, and even to be smelt. As this could only have come from the iron tube, it seemed probable that in passing the current of ammonia previously through the tube over the titanium dioxide to form the dinitride, some of the iron had become converted into iron nitride, which was subsequently reduced by hydrogen, giving ammonia. In hard Jena glass, and using a gas furnace, and up to the highest temperatures attainable with this combination, no reduction of either of the nitrides of titanium was observed.

As ammonia gas passed over the oxide at a red heat gave the dinitride, the possibility of being able to attain the same result by passing a mixture of nitrogen and hydrogen over the dioxide at a red or white heat suggested itself. This was tried at temperatures ranging from a low red heat to 1,500° C., using a silica tube, but no nitride was formed, the dioxide being simply reduced to black titanous oxide. As this experiment was not successful, and as hydrogen is more active as a reducing agent in the presence of finely divided nickel, another similar experiment was performed in which the titanium dioxide was mixed with an equal weight of nickel oxide, and the whole finely ground and then reduced with hydrogen at 350° C. A mixture of hydrogen and nitrogen was passed over it at this temperature, but no nitride was obtained, although a small trace of ammonia was present in the issuing gas.

An attempt was also made to produce a nitride of titanium by heating the sulphide in a mixture of hydrogen and nitrogen. The sulphide was obtained by heating titanium dioxide in a current of carbon bisulphide vapor to a red heat. 2.073 grms. of the sulphide ignited to dioxide gave 1.495 grms., equal to 43.2 per cent of titanium; this agrees approximately with the 42.8 per cent required for the formula TiS_2. During the attempt to produce the nitride by this method, hydrogen sulphide was evolved but no nitride obtained, only a lower titanium sulphide, the percentage composition of which agreed with the formula, Ti_2S_3. The experiment was conducted with 2.199 grms. of the sulphide, during which a loss of 0.284 grms. took place, which corresponds to a loss of 12.9 per cent of sulphur.

As *boron* compounds are cheap, it was decided to make a few experiments involving the use of this element before proceeding any farther with the rarer materials of the earth's crust. The result of the first set of experiments may be summarized as follows: Boron nitride cannot be produced by heating boron trioxide in a mixture of hydrogen and nitrogen, but if carbon is used as the reducing agent instead of hydrogen, then a certain quantity of nitride is formed. This quantity may be considerably increased if a mixture of carbon and iron, prepared by heating pitch and iron together, was employed instead of the carbon alone. A temperature of about 1,200° C. was used. However, even under the best conditions, only such a small quantity of nitrogen was "fixed" that the method is of no technical importance.

A quantity of boron nitride was prepared by the well-known method of heating a mixture of borax and ammonium chloride. The direct reduction of this nitride was attempted by heating it at various temperatures up to a white heat in a stream of dry hydrogen, but without success. Dry hydrogen sulphide was passed over boron nitride at the highest temperature attainable, using a gas furnace and hard Jena-glass tubing, but they were entirely without action on one another. A still more striking instance of the great stability of boron nitride was shown by passing dry hydrogen chloride over the nitride at a temperature of 1,470° C. The nitride was entirely unaffected by this treatment. From these experiments it is obvious that it is impossible to use boron nitride as a carrier between atmospheric nitrogen and ammonia, as the only reasonable way to obtain ammonia from the nitride is to heat it in a current of steam; but if this is done, it is impossible to re-form the nitride from the trioxide and atmospheric nitrogen, as was demonstrated by the first experiments undertaken with boron.

The next experiments were made with *cerium* nitride, prepared by means of the thermit reaction. The calculated quantity of cerium dioxide was mixed with the equivalent quantity of powdered magnesium and heated in an atmosphere of nitrogen. By this means a mixture consisting principally of cerium nitride and magnesia was obtained. The direct reduction of cerium nitride with hydrogen was tried and it was found that at a dull red heat ammonia was slowly evolved, the cerium combining at the same time with excess of hydrogen forming cerium hydride. Experiments were now performed to find out whether the reverse action could be induced to take place, namely, the conversion of the cerium hydride by means of nitrogen into cerium nitride and ammonia. Cerium hydride was therefore prepared by an exactly analogous method to that used in the preparation of the nitride, namely, by heating a mixture of cerium dioxide and magnesium powder in an atmosphere of hydrogen; this gave a mixture of cerium hydride and magnesia. A rapid current of nitrogen was then passed over the hydride, and the temperature gradually raised to a bright red heat. During the experiment small quantities of ammonia were evolved, while it was subsequently found that the hydride had been converted into nitride. The small yield of ammonia was probably due to the high temperature having decomposed the greater part of it into its elements, for ammonia begins to decompose at 500° C. (Ramsay & Young, Trans. Chem. Soc., 1884.)

On a laboratory scale, and using hydrogen and nitrogen absolutely free from oxygen, carbon monoxide, and water, the oscillation from cerium hydride to cerium nitride and back again can be made to go on indefinitely; during each cycle obtaining hydrogen and nitrogen perfectly free from oxygen

would go far to bar this process from being a commercial success.

Another process of purely theoretical interest could be carried out with vanadium, columbium, or tantalum. It has been shown by von Bolton (*Zeit f. Elektrochemie*, 1905) that the metal is produced if any one of the oxides is heated to a white heat in a vacuum of less than 20 mm. pressure. Nitrogen instantly reacts with the white hot metal giving the nitride (VN). This nitride reacts with steam at 400° C. giving ammonia and the oxide.

Experiments with molybdenum and tungsten were no more successful, as far as working out a "fixing" process was concerned, for although both these elements form nitrides, neither appears capable of combining directly with molecular nitrogen. Working with finely divided tungsten, and at temperatures as high as 1,500° C., no appreciable quantity of nitride was formed.

The elements thus divide themselves naturally into two groups. As an example of the one class may be mentioned the element tungsten, the nitride of which, though directly reducible, cannot be formed directly from its elements; while magnesium, boron, and titanium afford examples of elements which combine directly with nitrogen, but of which nitrides are not reducible directly, so that the only way to obtain ammonia from these nitrides is to act upon them with steam; nevertheless, as these oxides are not reducible, the cycle cannot be completed.

It may be urged at first sight that the experiments with cerium contradict this view; but that is only apparent, for the reduction in this case is probably due to the extraordinary affinity of cerium for hydrogen, which displaces the nitrogen, forming cerium hydride, while the production of ammonia may be looked upon as a secondary reaction in which the displaced and nascent nitrogen combines with the excess of hydrogen present.

Corrosion of Iron.

On page 254 of our July issue we commented on the corrosion of iron as an electrochemical phenomenon, with reference to a paper of Dr. Allerton S. Cushman, before the Society of Testing Materials. This paper has now been published in full as Bulletin No. 30 of the Office of Public Roads of the United States Department of Agriculture. Another paper on the same subject was presented by Dr William H. Walker, Miss Anna M. Cederholm and Mr Leavitt N Bent, in May, before the New York Section of the American Chemical Society, and will be published in full in the *Journal* of the American Chemical Society We herewith give abstracts of both papers. We also comment on the subject on our editorial pages.

* * * *

The paper by Dr. William H. Walker, Miss Anna M Cederholm and Mr. Leavitt N Bent is an account of an important experimental investigation carried out in the Research Laboratory of Technical Chemistry of the Massachusetts Institute of Technology.

After a review of the carbon-dioxide theory, the electrolytic theory and the hydrogen-peroxide theory of the corrosion of iron, the authors discuss especially the experiments of G. T Moody, which are believed by this author to prove the correctness of the carbon-dioxide theory Dr Walker and his associates have repeated these experiments and confirmed them, but differ strongly from Moody as to the conclusions Moody's paper was published in the *Journal* Chemical Society (London), 89,720.

The fact that Moody could not detect any rust on iron in pure water without carbon dioxide, is attributed to the fact that Moody's iron had previously been treated by chromic acid, whereby it had assumed the so called passive state Further experiments of Dr. Walker showed conclusively that iron dissolves in pure water free from oxygen and carbon-dioxide Hence carbon-dioxide is not essential for the corrosion of iron. The experiments on this point are described as follows

"A round-bottom Jena flask of about 1 liter capacity is inverted on a nozzle supplying live steam for at least 24 hours This insures the removal of any easily soluble alkalies which would otherwise destroy the neutrality of the liquid The flask is fitted with a carefully cleaned rubber stopper, through which extends a glass tube drawn down to a moderate sized capillary at its upper end. The flask is three-fourths filled with ordinary distilled water (not conductivity water) which has previously been boiled for several hours in a block-tin heater The water in the flask is boiled for about 10 minutes, and while steam is still rapidly passing out of the opening the stopper is removed and a piece of bright iron introduced. The stopper is again inserted, the boiling continued for another 10 minutes, and while boiling the capillary is sealed The flask is allowed to cool after thickly coating the stopper with molten paraffin. If this experiment be carefully performed no action will be observed, the iron remaining bright and the water clear even after standing several days. When the stopper is removed and the water concentrated in a platinum dish, using every precaution to prevent a contamination from dust, a strong test for iron can always be obtained by the use of any of the ordinary reagents.

"Thinking that possibly enough gas had been occluded in the iron to effect the reaction the above experiment was repeated a number of times under conditions which allowed of introducing pieces of iron which had been heated to low redness and cooled in hydrogen. In every case the presence of iron was easily detected when the contents of the flask was evaporated to a few drops.

"This experiment was again repeated with the additional precaution of using water which had been allowed to stand for a number of days over a large quantity of spongy, metallic iron reduced with hydrogen and introduced into the reaction flask by distilling it from the iron in an atmosphere of hydrogen. Notwithstanding all these precautions, a distinct test for iron was obtained after the water had been concentrated

"We, therefore, support Whitney in his statement that iron will dissolve in water which contains not more than a trace of electrolyte, no oxygen and only that amount of carbon-dioxide which is not retained by strong alkalin hydroxide In explanation of the failure of the investigators, previously cited, to detect dissolved iron we would state that usually it is not possible to obtain an indication of iron with potassium ferricyanide; for example, in the water as it comes from the flask concentration generally is necessary."

The authors then describe a direct demonstration of the electrolytic character of the corrosion of iron by means of a special indicator devised by them and Dr Allerton S Cushman

A piece of iron is immersed in ordinary water to which has been added a little phenolphthalein and a trace of potassium ferro-cyanide. Within a very few minutes the iron is seen to divide itself into zones or surfaces which exhibit opposite polarity Those portions where the iron is anode become coated with a precipitate of Turnbull's blue, owing to the escape of the iron ions at those points. These portions of which hydrogen is being liberated, acting as cathodes, become bright red owing to the formation of hydroxyl ions This action may be more easily studied if this reagent (one which Dr Cushman has proposed the name "ferroxyl") be thickened by the addition of natural gelatin or agar-agar (See below)

Then follows a particularly interesting part in the paper of Walker and associates dealing with the function which oxygen plays in the corrosion of iron Of course, oxygen is necessary for rusting, according to the electrochemical theory the first

action is the passing of iron into the ferrous ionic state, with simultaneous liberation of hydrogen; the ferrous ions are then oxidized to the ferric by oxygen in the atmosphere, with its subsequent precipitation as ferric hydroxide. This is the evident secondary function of oxygen.

But according to Dr. Walker oxygen also has to fulfill a primary function in the corrosion of iron.

The rapidity with which iron will pass into solution in water depends not only upon the electrolytic solution pressure of the iron and hydrogen and the osmotic pressure of the iron ions already in solution, but also upon the "excess voltage" (überspannung) which is required in order that the hydrogen ion which passes from the ionized condition may be set free. In this case there is a counter electromotive force which must be overcome before the hydrogen can be liberated. It is possible, therefore, that the quantity of iron which can dissolve in water is limited to that amount which is equivalent to the hydrogen necessary to polarize that portion of the specimen which acts as the cathode. If this is so, it must be possible to make the solvent action continuous by the addition of any reagent which will dissolve the hydrogen-covered cathode portion.

The matter is made quite clear by the following experimental arrangement of Dr. Walker: Within a jar there are placed two unglazed porcelain cups, acting as porous cups, concentric with each other with the jar. We have, therefore, in the center a cylinder and around it two annular spaces. The three spaces are filled with hundredth-normal KCl, free from oxygen and carbon-dioxide, and the whole is placed upon a hot plate of a temperature to insure continuous boiling. Two pieces of clean, pure iron, joined by an iron wire, are introduced into the central and outside compartments, and the whole while still boiling vigorously is sealed by a metallic cup. Hydrogen is allowed to enter as the jar cools, so as to release and prevent leakage. Such a cell may be maintained for many hours without dissolving enough iron in either compartment to be detected by potassium ferricyanide in its unconcentrated condition. When reduced to a few drops, however, iron may always be shown to be present. Portions of each iron plate may be assumed to be anodic with iron tending to go into the ionized form, and other portions cathodic, being polarized by a film of hydrogen.

If, now, a substance which will dissolve away the hydrogen be added to one compartment, the cathodic portion of the iron contained therein should be depolarized and the action should result in the solution of the anodic portions. Since the two pieces of iron are short-circuited above by a wire and below by the electrolyte, that piece which is continually depolarized would be expected to become the cathode and the other the anode. Hydroxylamine serves as such a depolarizer.

By passing a stream of hydrogen gas through all three cups the boiling and cap may be dispensed with, and iron will not dissolve in 6 hours sufficiently to give directly the ferrocyanide test. If the hydrogen stream in one compartment be replaced by oxygen, iron will immediately begin to dissolve at an appreciable rate in the other compartment, separated though it is by the intermediate compartment through which hydrogen is passing. The dissolved iron in the anode compartment remains in solution as a ferrous salt while the cathode compartment becomes strongly alkaline. If the porous cells be withdrawn the iron at once oxidizes and is precipitated as brown ferric hydroxide.

The primary function of oxygen in the corrosion of iron is, therefore, to depolarize those cathodic portions of the iron upon which hydrogen tends to precipitate.

The influence of the depolarizing action of oxygen may be conveniently studied by using the ferroxyl indicator. For example, in a beaker may be placed a porous earthenware cell and the whole filled with ordinary water containing phenolphthalein and a very little ferricyanide. If a piece of iron be placed within the cell and connected by means of an iron wire with a piece of platinum in the outside compartment, immediate action takes place, deep red appearing on the platinum and a coating of blue precipitating on the iron. If, however, the platinum be heated in an alkaline pyrogallate solution, washed in boiling distilled water, and while wet used as the cathode in the cell, no action will take place for a number of hours. Only as the platinum takes up oxygen from the atmosphere does the reaction become apparent.

Another conception which differs only in the point of view from the above is to consider the metal which acts as a cathode, for example, the platinum, as an oxygen electrode, and that the current flowing through the circuit (on account of which the iron dissolves) is due to the solution of the oxygen and the formation of hydroxyl ions charging the solution negatively, and thereby requiring a solution of iron at the other electrode to bring about electrostatic equilibrium. When viewed in either of these two lights the action should be proportional to the concentration of oxygen in the solution, and, hence, according to the laws of Henry and Dalton, to the partial pressure of the oxygen in the atmosphere above the solution. This conclusion was indeed experimentally confirmed by Dr. Walker.

The fact that the accelerating action of increased pressure of oxygen may be looked upon as due to an oxygen electrode, has an interesting bearing upon Dunstan's theory of the intermediate formation of hydrogen peroxide. Richarz and Lonnes (*Zeit. f. physik. Chemie*, 20, 145) decomposed water saturated with air by passing through it, between platinum electrodes, a current of low electrode density. They found that at the cathode the hydrogen was to a large extent not liberated as such but that it combined with the dissolved oxygen to form hydrogen peroxide. These are exactly the conditions which obtain upon the cathodic portions of iron undergoing corrosion, except that there here we have iron instead of platinum. The appearance of hydrogen peroxide is, therefore, to be expected, provided it can exist on an iron surface.

The formation of hydrogen peroxide if it takes place must, therefore, be considered incidental to and not necessary for corrosion. An electric current can pass between bright iron and iron covered with scale only (1) if the concentration of the hydrogen ions be increased by the presence of an acid, or (2) if oxygen or some other depolarizing substance be present.

If a piece of chemically pure iron, free from mechanical strains and without evident crystallization, be immersed in the ferroxyl indicator, the positive and negative zones will be indicated after a few moments. There appears to be an unequal concentration of oxygen or segregation of oxygen upon the surface which cannot be explained by discernible differences in the character of the surface. If the ferroxyl indicator be removed, the surface cleaned by rubbing with a dry towel and the indicator again applied, the same separation into zones is seen, though in an entirely different configuration. The indicator is apparently a very delicate one and susceptible to changes in equilibrium which up to the present have not been detected.

It is significant that from comparative tests made between samples of iron, which had proven in practice as specially resistant to corrosion, and others which had proven as specially susceptible to corrosion, it was found that areas showing marked differences in potential exist in far greater number upon the surface of the piece of iron subject to corrosion than upon iron which is resistent to corrosion.

* * * * *

Dr. Allerton S. Cushman's paper as published in full as a pamphlet of the Department of Agriculture will be found very interesting reading. The photographs which are reproduced in the pamphlet, representing the cathode and anode zones on corroding iron surfaces as indicated by the ferroxyl reagent, are very pretty, but it is to be regretted that they are not reproduced as colored tables.

Dr. Cushman's paper begins with a review of the different theories of the corrosion of iron and criticisms of Moody's experiments. Like Dr. Walker, Dr. Cushman considers that Moody's experiments are not a conclusive proof of the carbonic-acid theory. With respect to the electrolytic theory he points out that since iron has been shown to rust in the presence of pure water and oxygen alone, and since according to the electrolytic theory the corrosion by oxygen is a secondary process, the assumption of electrolytic action as a fundamental cause of the wet oxidation of iron must stand or fall on the determination of one crucial question, namely, whether iron passes into solution even to the slightest extent in pure water. Like Dr. Walker, Dr. Cushman has been able to confirm experimentally Whitney's result that this fundamental question must be answered in the affirmative.

In discussing the stimulating and inhibiting effects of certain substances on the corrosion of iron the rationale of the protective effect of chromic acid and potassium bichromate is discussed at length. If a rod or strip of bright iron or steel is immersed for a few hours in a strong (5 to 10 per cent) solution of potassium bichromate, and is then removed and thoroughly washed, a certain change has been produced on the surface of the metal. The surface may be thoroughly washed and wiped with a clean cloth without disturbing this new surface condition. No visible change has been effected, for the polished surfaces examined under the microscope appear to be untouched. If, however, the polished strips are immersed in water it will be found that rusting is inhibited. An ordinary untreated polished specimen of steel will show rusting in a few minutes when immersed in the ordinary distilled water of the laboratory. Chromated specimens will stand immersion for varying lengths of time before rust appears. In some cases it is a matter of hours, in others of days or even weeks before the inhibiting effect is overcome.

Dr. Cushman shows why the formation of a protective thin film of either oxide or chromate on the surface of the iron is not a satisfactory explanation. On the other hand, it is a fact that if polished iron is allowed to stand for some time in standard tenth-normal potassium bichromate solution, the oxidizing strength of the latter, as measured by its titration value, is slightly reduced without the solution of the iron or the production of any visible effect. Under the same conditions a standard solution of neutral potassium chromate is slightly reduced with the appearance of a small amount of chromic hydroxide. In fact, all the evidence obtainable points to the abstraction by the iron of some of the available oxygen of chromic acid and its salts without the formation or solution of iron oxide films.

Dr. Cushman believes that the passivity of iron is best explained as a "polarization effect produced by the separation and retention of oxygen on the surface of the metal." The iron is brought to the condition of an "oxygen electrode."

The second part of the paper is devoted to the demonstration of electrolytic action in the corrosion of iron by means of the ferroxyl indicator. "Many persons who are interested in the metallurgical problems connected with the iron and steel industry may not be familiar with the modern theory of indicators, and therefore an explanation of the manner in which phenolphthalein shows the presence of hydroxyl ions by the formation of a pink color will not be out of place. Phthalic acid was first prepared by Laurent in 1836 by the oxidation of napthalene, and was first called napthalinic acid. It was afterwards shown that the compound was not directly related to the napthalene structure and Laurent changed the name to phthalic acid, the derivatives of which became known later as phthaleins. Phenolphthalein is a product which is formed by the condensation of two molecules of phenol or carbolic acid with the anhydride of phthalic acid. It is in its nature so weak an acid that it is not dissociated in solution, and as the molecule is colorless, no color is seen when it is added to a perfectly neutral solution. If, however, an alkali is added the corresponding salt of the weak acid is formed, which immediately dissociates with the formation of a colorless metallic cation and the strongly rose-colored organic anion. Thus all hydroxides of basic elements will show the pink color in solution, even when present in only the slightest excess. On this account phenolphthalein is an exceedingly delicate indicator of the presence of hydroxyl ions." Dr. Cushman proposes to call it phenolin.

At a suggestion of Dr. W. H. Walker a trace of potassium ferricyanide is added to the reacting solution, in order to furnish an indicator for the ferrous ions whose appearance mark the positive poles. If iron goes into solution, ferrous ions must appear, which, with ferricyanide, form the well-known Turnbull's blue compound. Going a step further, Walker suggested stiffening the reagent with gelatine and agar-agar, so as to prevent diffusion and preserve the effects produced. This combined reagent is called ferroxyl and prepared and used as follows: "A hot solution of the purest agar-agar or gelatine in distilled water is carefully neutralized with one-hundredth normal potassium hydroxide, using phenolphthalein as the indicator. When exact neutrality has been obtained a few drops of a dilute solution of potassium ferricyanide is added. When a layer of the reagent is poured into a dry Petri dish floating in ice water it should stiffen into a firm jelly in a few minutes. The polished specimens are laid carefully on the jelly and flooded with another layer of the reagent. After the preparation has hardened it should be covered and set away in a cool, dark place. In the course of a few hours the negative and positive zones will begin to develop in red and blue. If the reagent has been properly prepared the color effects are strong and beautiful. In the course of a few days the maximum degree of beauty in the colors is obtained, after which gradual deterioration sets in." The blue areas which appear represent the positive nodes while the pink areas represent the negative nodes, so that these two nodes represent the two electrodes of the short-circuited galvanic cell which causes the solution of the iron with subsequent rust formation.

While some samples of corroding iron show localized electrolytic action, as indicated by deep pitting, others become covered with a more or less homogeneous coating of hydroxide, which shows little or no tendency to localize in spots or nodes. The underlying reason for this behavior is explained by the use of the ferroxyl indicator. In the first case the positive and the negative poles of the short-circuited couple remain at their place. At the anode iron continually passes into solution, and the surface is pitted, while at the cathode hydrogen is set free. The ferrous ions in solution near the anode are rapidly oxidized to a loose colloidal form of ferric hydroxide. According to whether a negative zone surrounds the positive pole or a positive zone surrounds a negative pole we have to expect the piling up of rust in a crater formation with the metal eaten out at the center or the piling up of rust in a cone at the center with the metal being eaten up around it. That this really takes place is shown by means of micro-photographs.

In the other case in which iron becomes covered all over with a somewhat homogeneous coating of hydroxide, the investigation with the ferroxyl indicator shows that we have to do with an electric system in which the poles change from time to time. What was first anode becomes later cathode and what was before cathode becomes anode.

The best demonstration that the rusting and corrosion of iron and steel in all its forms is essentially an electrolytic phenomenon is afforded by the fact that it has not as yet been possible to find a specimen of such purity that no trace of positive and negative nodes will be formed in the ferroxyl indicator.

There are two possibilities to inhibit rusting. The first is to make the iron so pure and to guard against homogeneity and bad segregation to such an extent that couples are not likely to be formed. The second method is to use the present com-

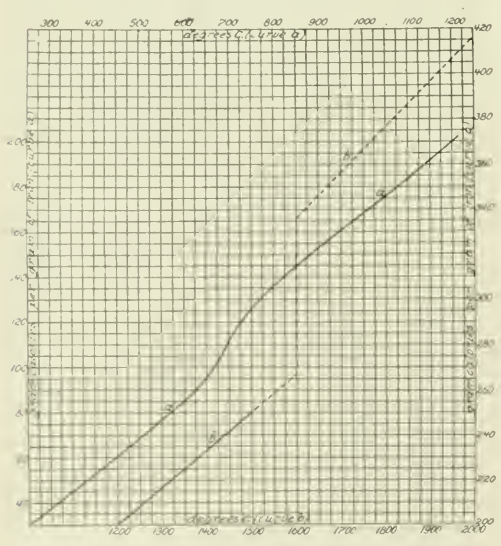
...ron and steel and protect it by a coating such as a ...ure soft oil containing bichromate.

The experiment has been made by Dr. Cushman of keeping iron and steel in dilute boiling solutions of bichromate for protracted periods at the same time that a current of air was bubbling through the boiler, and as long as the strength of the solution was equal to or above one one-hundred and sixtieth normal no rusting has ever taken place. Since this strength is approximately equivalent to 1 pound of the salt in 1,500 gallons of water, there seems to be no reason why potassium bichromate should not come into use as a boiler protective. The application of the various inhibitors in the priming coats of paints and other protective coverings has already been to some extent made use of, and it would appear that slightly soluble chromates should be theoretically the best protectives for the first application to iron and steel surfaces.

"Although it is true that laboratory tests are frequently unsuccessful in imitating the conditions in service, it nevertheless appears that chromic acid and its salts should under certain circumstances come into use to inhibit extremely rapid corrosion by electrolysis."

The Heat Content of Iron.

Dr. Engineer P. Oberhoffer contributes to *Metallurgie* of June 22, July 8 and 22, the full story of his researches on the specific heat of iron. It is a pity that some of Prof. Burgess' pure electrolytic iron was not used; instead, some soft steel from Krupp's was used, containing 0.06 carbon, 0.005 silicon,



ENERGY CONTENT OF IRON.

(Curve *c* is the continuation of curve *a*. The scales for curve *a* are at the left and the top, the scales for curve *b* are at the right and the bottom.)

0.005 phosphorus, 0.019 sulphur, and 0.05 per cent manganese. Cooling curves showed arrests in the speed of cooling culminating at 890°, 750° and 680° C.

The specimens were heated in a vacuum, and the heat unit is referred to water at room temperature. The results showed the specific heat of alpha iron to increase regularly, while that of gamma iron is practically constant, thus supporting the earlier determinations of Pionchon.

The actual results obtained by Oberhoffer are given in the following table, and are plotted in the annexed diagram, showing the gram calories contained per gram of iron:

°	Cal.	°	Cal.
250°	30.5	1200°	200.0
300°	37.7	1250°	208.3
350°	45.0	1300°	261.1
400°	52.2	1350°	224.2
450°	60.3	1400°	233.1
500°	68.3	1450°	241.4
550°	76.7	1500°	250.0
600°	85.0	1550°	258.3
650°	95.1	1600°	266.7
700°	111.8	1600°	336.
750°	125.6	1650°	346.
800°	135.8	1700°	356.
850°	144.4	1750°	366.
900°	152.8	1800°	376.
950°	160.4	1850°	386.
1000°	167.8	1900°	396.
1050°	175.4	1950°	406.
1100°	183.0	2000°	416.
1150°	191.7		

The inferences to be drawn from these figures are interesting and important.

First, we notice that the specific heat of iron rises from about 0.11 at zero to 0.144 at 250°, and to 0.166 at 600°; that between 650 and 700 there is an absorption of latent heat of about 10 Calories; again, about 750°, there is absorption of 7 Calories. About 850° there may be an absorption of 2 Calories, but the observation is somewhat doubtful. Above 900 the specific heat is nearly constant at 0.167. It is a curious fact that from 1,000° up to 1,500° the amount of heat in the iron, reckoned from 0°, is almost exactly 0.167*t*; *i. e.*, Sm to 0° is 0.167.

The figures above 1,500° (represented in the diagram by a dotted line) are estimated values which we have added to Oberhoffer's observations. Up to 1,600°, the assumed melting point, we have extended the last observation of the last paragraph, making $Q = 0.167t$. At the melting point we have taken the latent heat of fusion as lying between 69 and 70 Calories. The calculation of this quantity on thermochemical principles is too long to insert here, but may be found fully explained by J. W. Richards in the *Journal* of the Franklin Institute, May, 1897. This makes the heat in just melted iron 336 Calories.

From this temperature on the iron is liquid, and since the solid iron just before melting has a constant specific heat of 0.167, the specific heat of the liquid iron will in all probability (from analogy with other metals) be also constant and probably only slightly higher than in the solid state. We have completed the curve to 2,000°, using a specific heat of 0.20 for the liquid iron.

We think, from a close study of Oberhoffer's work, that he has probably given us the most accurate figures yet obtained for the heat in pure iron, and rounding out his observations by the probable values given and explained; we think these figures altogether are the most accurate which are at present available for use in the metallurgy of iron. Jos. W. Richards.

Electric Bleaching of Flour in England.—An interesting case with regard to an electric process for bleaching flour was recently decided in the London law courts, as noticed in London *Electrical Engineering*. The Alsop flour-bleaching process consists in passing a current of air through a chamber containing an electric arc, and thence through the flour to be bleached. The British patent covering this process has been revoked. The judge held that the bleaching agent was the oxides of nitrogen generated, and that flour bleaching by means of these gases did not constitute any novelty.

The Electrothermic Reduction of Iron Ores.

By Albert E. Greene and Frank S MacGregor.

This paper contains the results of an experimental investigation which was carried out by the authors in the electrochemical laboratory of the Massachusetts Institute of Technology on the electrothermic reduction of iron ores containing titanium. To Prof. Goodwin, under whose direction the research was undertaken, we desire to express our warm thanks for the facilities put at our disposal and for the assistance and encouragement which he has given us throughout the progress of our work

Investigations[1] up to the present time have demonstrated that iron ore can be economically smelted in the electric furnace where power is cheap; they have shown that the electric furnace does not differ essentially from the blast furnace from the metallurgical point of view; and, furthermore, that it has certain advantages in the regulation of temperature and localization of heat, which make it especially applicable for smelting refractory ores and for making special varieties of pig iron.

There are many phases of the problem, however, regarding which data are entirely lacking at the present time, and it was with the hope of making a contribution to certain of these that the following investigation was undertaken. The points to which we particularly directed our attention were:

1. The design and construction of an experimental electric furnace of about 30-kw. capacity.

2. The measurement of the temperature of the molten charge.

3. The factors affecting the temperature and the methods of regulating it.

4. The effect of temperature and of composition of charge on the quality of iron produced.

5. The calculation of the amount of electric energy required per ton of pig iron.

In planning our investigation it was necessary to start out with very little data regarding the best size and shape of the furnace, the character of materials to be used and the details of application of power, etc. The procedure followed was first to build the furnace, making its size and shape conform to the condition of power at our disposal, then to make preliminary runs with one of the Pacific Coast sands, of which a considerable amount was on hand. We thus obtained a working knowledge of the furnace, method of measuring temperature, etc., after which we proceeded to make runs on the regular iron ores, in which (a) the temperature was varied, keeping the charge constant, and (b) the charge itself was varied.

Ores Investigated.

Three samples of ore were obtained with which to carry out the investigation. Two of these were iron sands from the Pacific Coast, and the other was a titanium iron ore from Essex County, N. Y. The sands were used in the first six preliminary runs designed to test the best method of operating this furnace and measuring its temperature. They did not lead to conclusive results concerning their own possible value as a source of iron.

The ore upon which the results of this investigation are based contained practically no sulphur or phosphorus, its analysis being

Fe_2O_3	70.40%
SiO_2	1.99%
TiO_2	26.40%
Al_2O_3	Small
MnO_2	Small
Total iron	52.52%

It was crushed to about ¼ inch in a Blake crusher in preparation for the furnace. The best grade of Pocahontas coke was used as reducing agent, and the flux was burned lime used in the laboratories of the Institute, and consisted of almost pure CaO. No analysis of either coke or lime was made. These materials were used throughout all the tests.

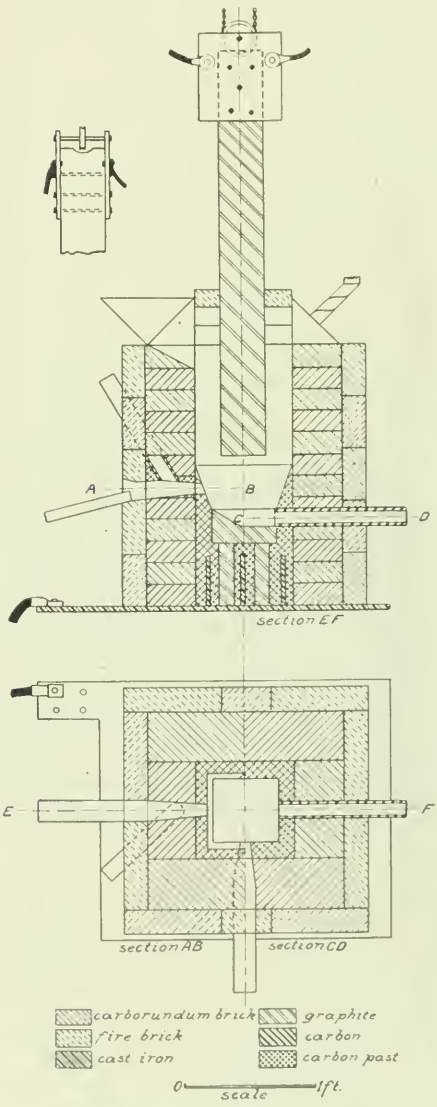


Fig. 1.—Experimental Electric Furnace.

Apparatus.

The power used in our experiments was alternating current. It was generated in a special 1,100-volt, 133 cycle, 30 kw. generator, belt driven by a 50 hp direct-current motor supplied with power from the power plant of the Institute. The energy was transmitted at 1,100 volts to the transformer in the furnace laboratory, from which it could be taken at voltage varying

[1] See especially the two reports by Dr. E. Haanel, this journal, vol. III., p. 479, and vol. IV., pp. 124 and 265.

from 10 to 160 volts and applied directly to the furnace. [The diagram of connections may be seen in plate.]

The electrical instruments used for measuring current, volts, etc. were an ammeter, A. C., 5 amps; a voltmeter, A. C., 65 volts, a wattmeter, A. C., 5 amps. and 65 volts; a current transformer; a voltmeter, D. C., 15 volts, and a galvanometer for the thermo-electric pyrometer.

The A. C. instruments were all General Electric instruments. They were not recalibrated, because the precision of the power measurements did not require it.

The temperature of the molten bath was measured by means of a Wanner optical pyrometer reading from 0° to 4,000° C. This instrument was calibrated at the Reichsanstalt, at Charlottenburg, Germany. The standard 6-volt lamp was supplied with current from a storage battery. This voltage was maintained constant by means of a slide-wire resistance in series with the lamp between the mains of the battery, and was read on the 15-volt Weston voltmeter.

A thermoelectric couple was used for getting the temperature of the gases. In stating results all temperatures are given in degrees centigrade and all weights in kilograms.

Description of Furnace.

The furnace was first constructed as follows: A plate of iron three-quarters of an inch thick was cast in the form of a rectangle 28 inches x 24 inches. A tongue 4 inches x 6 inches projected at one corner to which cables to the transformer were fastened. In the center portions of the plate five holes, $\frac{3}{8}$ inch in diameter, were bored $2\frac{1}{4}$ inches apart. Into these were firmly driven five iron rods 2 inches long, to aid the conduction of the current from the bed-plate into the crucible, which was to act as one electrode.

Carborundum bricks were laid in this cement around these rods, forming an enclosure 9 inches square and 9 inches deep. This space was filled with a mixture of granular coke and molasses, and the first crucible formed of this mass. Carborundum bricks were used to complete the crucible, around which a layer of fire-bricks was then placed, forming the outside of the furnace. Iron straps and bolts were used to fasten the furnace together.

A tap-hole for metal was placed on one side of the furnace, and on an adjacent side, about 2 inches above the metal hole, was placed a tap-hole for the slag. Conical carbon rods were used to form the tap-holes and also as plugs during the runs.

The other electrode was movable and consisted of a graphite bar 4 inches x 4 inches x 40 inches. The holder consisted of two brass plates, bolted to opposite sides of the electrode by bolts running through the electrodes itself. The plates projected above the end of the electrodes so as to support a small grooved pulley. An iron chain fastened to a crane gave an easy adjustment of the electrode, which could either be lowered to the bottom of the crucible or hoisted above the top. Four flexible copper cables were bolted to the supporting plates forming the other electrical connections.

On one side of the top of the furnace was placed a hopper for holding the charge, and the rest of the top was enclosed so as to enable the gases given off through a flue to be collected and analyzed as well as to determine their temperature. The information obtained from the first six runs caused us to introduce various changes in the crucible, and after many materials were used as a lining, flour carbon and molasses was found to give the most permanent and satisfactory results. Owing to the poor electrical conductivity of the coke paste a graphite block was finally used as crucible base, the block resting directly upon the metal bed-plate. The shape of the crucible was that of a frustum of a pyramid, the sloping walls extending upward about 8 inches, the rest of the wall being the carborundum bricks.

The dimensions of the furnace and crucible as finally used are as follows:

Height of furnace	24	inches.
Length of side	23	"
Depth of crucible	8	"
Size of upper portions of crucible	9	" square.
Size of base	5	" "
Distance from bottom of crucible to top of furnace	$15\frac{1}{4}$	"

Measurement of Temperature.

The development of a suitable method for obtaining the temperature of the molten charges, at the same time keeping the top of the furnace closed, required much experimenting. In the first runs the pyrometer was sighted through a carbon tube 1 inch internal diameter and 12 inches long, which was introduced diagonally through the furnace from the outside, into the molten charge. This was abandoned, as the molten mass solidified in the tube. In run No. 2 a thin carbon plug was put in the lower end of the tube mentioned above, but this did not attain the same temperature as the charge. In run No. 3 a carbon tube, closed at one end, was placed horizontally

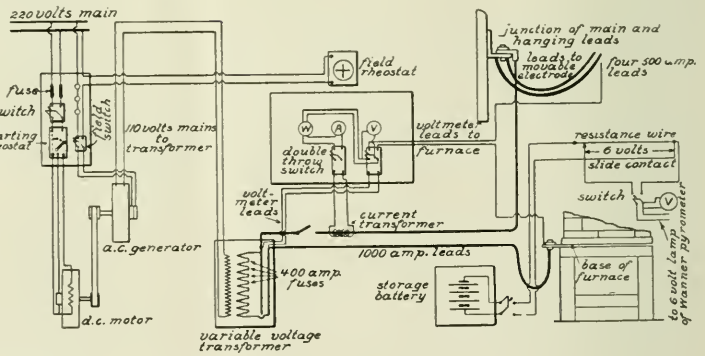


FIG. 2.—DIAGRAM OF CONNECTIONS.

through the furnace walls, so that the end formed a part of the base of the crucible itself.

With this arrangement the molten metal was in direct contact with the surface upon which the pyrometer was focused. As a check on observations made by this method another tube was so arranged with respect to the slag hole that when the plug was removed it would give a view of the outflowing slag just as it left the interior and before it reached the open air.

Readings by these methods checked well, but at times the plug became covered on the inside with a solid film, which had to be removed by poking. Later, owing to lack of time, when it became necessary to abandon the work on the gases the method of measuring the temperature was much simplified. With the furnace top partially open it was only necessary to sight the pyrometer upon a clear area made in the surface of the molten charge.

The five methods which we tried of determining the temperature of the molten zone were, therefore (1), open tube entering top of molten slag; (2) plugged tube entering top of molten slag; (3) horizontal plugged tube entering near base

of crucible; (4) open tube giving a view of outflowing slag just leaving interior; (5) using surface of charge as seen from the top of the furnace.

Of these the third seems the most satisfactory for a closed-top furnace; for an open-top experimental furnace no larger than that which we used the fifth method may also be used.

The primary factor in the temperature regulation is the amount of electrical energy put in. This is dependent on three things: the voltage, the current and the height of the electrode. In the first six runs the relation between temperature and these factors, taken separately, was more easily observed than in later runs, because of the large amount of slag present

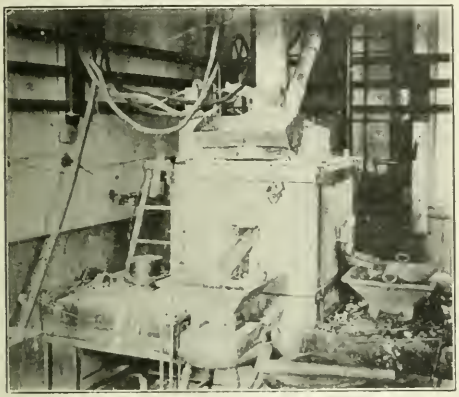


FIG. 3.—VIEW OF ELECTRIC FURNACE.

and the greater length of run, but these first runs did not give good working results and served mostly to show the mechanical action of the furnace and the above points. A wattmeter was used after run No. 5, showing the relation of power input and power factor.

The following points may be noted: The current tends to increase when no addition of charge or other change in conditions is made. This was most clearly shown in one of the runs where, to begin with, the current at 4.30 P. M. was 660 amps., and it increased to 810 amps in 12 minutes at 4.43 P. M. without any external change in height of electrode. This is probably explained by the fact that the charge became entirely molten and the electrical energy used in melting it served next to raise its temperature and therefore its conductivity.

The result of change of electrical input was most easily observed in run No. 6. At 3.15 P. M. the power input was increased from 16.5 kw. to 19.2 kw.; the temperature before the change was 1,204° C., at 1 minute after 1,222° C. 2 minutes after it became practically constant at 1,234° C. These facts show the readiness and ease with which the temperature may be regulated.

The power factor in our apparatus was approximately constant at 92 per cent. The best regulation for constant temperature was obtained in runs No. 13 and No. 14 by maintaining the input constant. Our experience shows that the temperature may be regulated by the energy input, by the current or voltage, and to a certain extent by the height of electrode, and that the temperature responds very quickly to these changes.

To maintain constant temperature with a constant rate of input of charge, the energy input must also be constant.

Description of Tests and Results

First. A series of six runs were made on one of the iron sands from the Pacific Coast. They did not furnish any definite information except as to means of measuring and regulating the temperature, and the details of these runs will therefore be omitted.

In runs from No. 7 to No. 14 the titanium-iron was made the basis of tests and a summary of the results of these runs is given below:

Run No. 7. Ore Treated—Titanium-Iron Ore.

The composition of the charge for this run was:

Ore	10 kgs.
Lime	2.28 "
Carbon	2.25 "
Length of run	55.0 minutes
Mean volts on furnace	23.7
Mean amperes	730
Mean kilowatts	16.6
Power factor	941
Working temperature	1,393°
Weight of metal in kgs	1.32
Weight of slag in kgs	4.03
Horsepower-years required per ton of pig	1.14

This run was made with a very basic slag at a comparatively low temperature, 1,393°, and the metal produced was analyzed for Si and Ti, while the slag was analyzed for iron.

The furnace was heated for about an hour before charging. The size of the reducing agent was increased from what it had been in previous runs to about ¼ inch, owing to the large loss of fine powder by burning in the upper part of the furnace.

The measurements of temperature in the furnace and of the

FIG. 4.—VIEW OF ELECTRIC FURNACE.

outflowing slag checked fairly well. The slag was quite fluid and the furnace emptied easily.

Run No. 10.

Composition of charge same as in run No. 7

Length of run	53 minutes.
Mean volts on furnace	28.4
Mean amperes	703
Mean kilowatts	20.8
Power factor	.928
Maximum temperature	1,593
Weight of metal produced in kgs	1.13
Weight of slag produced in kgs	1.60
Horsepower-years per ton of pig	2.25

In runs 8 and 9 the temperature readings were unsatisfactory. In run 10, as was intended, the same charge as used in run No. 7 was smelted at a higher temperature, and as before analyses of the products were made for Si and Ti in the metal and Fe in the slag.

It was decided next to change the composition of the charge, making it more basic. This was done in run No. 11.

Run No. 11.

Composition of charge:

Ore	10 kgs.
Lime	3.5 "
Coke	2.25
Length of run	31 minutes.
Mean volts on furnace	24
Mean amperes	1,038
Mean kilowatts	22.71
Power factor	.910
Maximum temperature	1,549
Weight of metal kgs	1.00
Weight of slag	.90
Horsepower-years per ton of pig	.97

The slag obtained in this run was quite infusible and would not run. This is probably due to the high lime content of the charge. The samples of metal obtained in runs No. 7 and No. 10, as well as in this run, were very hard and somewhat brittle. They did not have any blow-holes but contained graphite. No analyses for carbon were made, and it was impossible to investigate the effect of temperature on the carbon content because of lack of time. The metal and slag were analyzed as before.

Run No. 12.

Composition of charge same as in run No. 11.

Length of run	29 minutes.
Mean volts on furnace	31.1
Mean amperes on furnace	822
Mean kilowatts	23.8
Power factor	.928
Maximum temperature	1,655°
Weight of metal kgs	1.77
Weight of slag	2.27
Horsepower-years per ton of pig	.93
Total carbon in metal	3.40%

The carbon content of the metal in this run was determined and found to be 3.40 per cent. In this and previous runs the furnace top had been closed in order to collect samples of the gas and measure its temperature. This scheme was abandoned in further runs. It was next planned to smelt a charge very low in lime at the highest temperature obtainable with the power at disposal.

The metal obtained was finer grained than before and more malleable. The slag was more fluid than in run No. 11.

Run No. 13.

Composition of charge:

Ore	4 kgs.
Lime	0.3
Coke	.94
Length of run	24 minutes.
Mean volts on furnace	24.0
Mean amperes	1,005
Mean kilowatts	23.2
Power factor	.964
Maximum temperature	1,922°
Weight of metal in kgs	1.09
Weight of slag in kgs	1.71
Horsepower-years per ton of pig	1.22

Run No. 14.

Composition of charge same as in No. 13.

Length of run	12 minutes.
Mean volts on furnace	21.5
Mean amperes	811
Mean kilowatts	16.15
Power factor	.922
Maximum temperature	1,469
Weight of metal kgs	.605
Weight of slag kgs	1.365
Horsepower-years per ton of pig	.745

In the last two runs the best regulation of temperature was obtained. This was partly due to the good shape and the character of the crucible. The highest temperature obtained throughout the tests was in run No. 13, where the regulation of the temperature was very satisfactorily accomplished by decreasing the voltage and therefore the power.

The slags in these two runs were both very fluid, and the charge at the lower temperature did not seem to be more difficult to fuse or less fluid than the same charge at the higher temperature. There was a difference in the appearance of the metal reduced at the two temperatures, that at the higher having a fine fracture with blow-holes, while that at the lower temperature crystallized and contained a good deal of graphite.

The results of the analyses of the products of the last six runs, the composition of the charge, the quality of slag, temperature and electrical input are tabulated as follows:

Run No.	Ratio $\frac{CaO}{Al_2O_3 + SiO_2 + TiO_2}$	Per Cent. SiO_2 in Metal.	Per Cent. Ti. in Metal.	Per Cent. Fe. in Slag.	Temperature of Molten Charge Degrees C.	Quality of Slag	Electric H.P. Years per Ton of Pig.
7	$\frac{2.25}{2.90}$	0.10	0.00	2.95	1375	Medium fluid..	1.14
10	"	0.11	0.00	7.10	1593	Fluid.. ...	2.25
11	$\frac{3.50}{2.90}$	0.13	0.00	6.37	1549	Infusible and viscous.. ...	0.97
12	"	0.23	0.00	7.56	1675	Infusible and viscous..	0.93
13	$\frac{.75}{2.90}$	0.30	0.20		1922	Very fluid. .	1.22
14	"	0.44	0.04		1469	Very fluid.....	.79

The results of the tests on the reduction of SiO_2 show, as would be expected, that the reduction increases with the temperature, but general conclusions as to the amount of SiO_2 that would be reduced at other temperatures cannot be drawn from these tests owing to the lack of sufficient data.

The analyses show that for a given charge the amount of iron slagged off increases with the temperature; increasing the temperature therefore tends to have the opposite effect to increasing the basicity of the charge.

The conditions under which the reduction of titanium ore to the metal begins are very important for the smelting of such ores. It was with the intention of determining these conditions that the great variation in lime content of the charge was made and the results were successful. The analyses of the reduced metal show that no titanium was reduced until the lime content of the slag was made small. In run No. 13 the ratio of the weight of CaO in the charge to the $Al_2O_3 + SiO_2 + TiO_2$ was $\frac{.75}{2.90}$, and at the temperature 1,922° of this run the amount of titanium in the metal was 0.22 per cent. At the lower temperature 1,469° of run 14, but using the same charge, only 0.04 per cent was found in the metal.

In none of the previous runs in which a higher per cent of lime was used in the charge was titanium reduced at all. The tests indicate, therefore, the character of the charge and the temperature limits for which no reduction of titanium takes place.

The observations on electrical input were not primarily taken with the idea of obtaining data on the efficiency of the electric furnace, but rather to show the relations between power input and the resulting temperature; nevertheless, the results are very good when the small size and relatively large radiating

surface of the furnace are considered. The lowest amount of energy required in any run per ton of metal reduced was found to be 0.75 electric horsepower-years.

The results of run No. 13 show that in order to smelt a charge at 1,922° C., the amount of electrical energy required in excess of that needed to smelt the same charge at a temperature 453° C. lower was 0.475 electric horsepower-years. It is probably quite accurate, because the run at the lower temperature was made immediately after that at the higher temperature, so that the reduction should be approximately constant. These facts should hold then for the same charge in a larger furnace.

Owing to lack of time further data, making possible the calculations of the amounts of heat required at the two temperatures were not obtained. The field for experimental work along the line followed in the tests is very broad, and it is to be hoped that the work may be extended in the near future.

Massachusetts Institute of Technology, Boston, Mass.

Transmutation of Elements.

So many remarkable statements have been recently published in the daily papers on the alleged experimental transmutation of copper into lithium by Sir William Ramsay that it is interesting to give herewith an abstract of his paper read on Aug. 2 before the British Association for the Advancement of Science. The paper was entitled "On the Variability in the Products Resulting from Changes in Radium Emanation." The following abstract is taken from the London *Electrician*, Aug. 9:

The author commenced by reminding his audience that radium, actinium and thorium all yield helium, and then proceeded to describe the results of experiments which are nothing short of remarkable. It is known that the emanation decomposes water with the liberation of excess of hydrogen, but where this excess of hydrogen comes from nobody knows. Sir William Ramsay exposed a solution of copper sulphate to the emanation for about a month, and at the end of that time the residue obtained gave the spectra of both sodium and lithium. The experiments were repeated three times, and the results were perfectly consistent in each case. The presence of sodium was not, of course, surprising, as the containing vessels used were composed of glass, but all the materials were tested for lithium, and there was not a trace before the experiments were commenced. Nevertheless, Sir William Ramsay expressed a doubt as to whether the quantity of sodium found could have all come from the glass, and he is going to undertake further investigations in this direction.

His next experiment was with copper nitrate, when lithium was again detected after a solution had been exposed to the emanation. Fresh copper nitrate not so treated with the emanation showed no sign of the presence of lithium. In both cases, however, sodium sulphate was detected, but the treated substance showed just twice as much (1.6 milligrammes) as the untreated substance. On evaporating water treated with the emanation, 0.3 milligramme of solid was obtained, while the inactive gas produced was neon with a trace of helium. Gases from the treated copper nitrate solution contained argon, with possibly a trace of neon. He remarked that 1 cubic cm. of emanation gives off $3^{1}/_{2}$ million times as much energy as 1 cubic cm. of a mixture of hydrogen and oxygen when exploded, and suggested that some of this vast amount of energy might account for the presence of the elements which he has found.

In the discussion which followed, the Hon. R. J. Strutt confessed that he could not find any source of error in Sir William Ramsay's experiments to account for the presence of neon in the case of water and emanation. He made a rough calculation in order to determine how much air would be required to provide the amount of neon (0.5 cu. mm.) obtained by Sir William, and found that it was about 100 cubic mm. In these circumstances he was sure that there could not have been such a large leakage of air to the apparatus as would account for this quantity. He further mentioned that there was quite sufficient lithium in quartz vessels to give a very distinct spectrum.

Prof. Rutherford complained that the amount of radium in the possession of experimenters was deplorably small. There were only about two laboratories in the world that were in a position to repeat Ramsay's experiments, and if only an experimenter could have a gramme instead of 100 milligrammes at his disposal there would be a very great deal more work done.

Prof. H. E. Armstrong, F. R. S., put forward the suggestion that the so-called inert gases are in reality very active, and that they are not monatomic at all.

In reply, Sir William Ramsay said that helium, when passed through a bath of liquid hydrogen, gave up a considerable amount of krypton.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

The Engineering Conference of the Institution of Civil Engineers.

Mining and Metallurgical Section.

The papers presented solely to this section were mostly concerned with mining matters. The first paper, by Mr. G. A. Denny, dealt with "Problems of the Witwatersrand Goldfields." For deep winding the author inclined to the electrical double-stage system; and he considered that the existing system of stamp mills, with cumbersome tailing and slime treatment plants, was economically and scientifically wrong; and that the future would witness a resort to simple methods of stage crushing, stage grinding, circulation of cyanide solution and final filter pressing. For underground mining he favored the utilization of traveling conveyor belts. Owing to excessive capital costs for shafts—£40 to £50 per foot equipped—each one should command a large mining area. The distances between shafts would in future probably be at least 1 mile. To connect them underground will occupy four years. The problem will be to ventilate the mines during the four years prior to connection. The cross-sectional area of the shafts may be taken as 200 square feet, the average barometer 24¼ inches, and mean temperature 61° F. The rock temperature at 4,000 feet on the Rand is estimated at 85° F., a figure much below that of other fields. Mechanical ventilation, at present practically unknown on the fields, must be practiced in future. For power transmission electricity and compressed air are used. The average efficiency secured from the former does not exceed 50 per cent, that of the latter does not exceed 6 per cent. The problem is to raise these efficiencies. For pumping the author inclines to the hydraulic pumping system, though the great advantages to the baler, when small quantities only are to be dealt with, probably render it superior to any system of pumping.

Next came papers by Prof. Henry Louis and Mr. C. E. Rhodes upon the subject of mine shafts. Prof. Louis' paper on "Special Methods of Shaft Sinking" appealed chiefly to coal miners, as it was confined to the means which have to be resorted to when ordinary methods cannot be applied economically on account of excessive influx of water. The largest amount of water successfully sunk through appears to have been at Horden Colliery, where 9,250 gallons of water per minute at a depth of 540 feet were dealt with. When the water bearing strata are firm ground the Kind-Chaudron method of boring shafts is mostly used. Since its introduction in 1854 about eighty shafts have been sunk by it, of which five

have been in Great Britain, at the Cannock and Huntington Colliery, at the Whitburn Colliery and at Dover. When the water-bearing ground is running three groups of methods are resorted to, namely, (1) Driving down annular sheet piling; (2) forcing down continuous cylinders of brickwork or iron, and (3) the Poetsch freezing process. The first method is not often seen now, but a good modern example is afforded by the recent sinking at Bowburn Colliery. Ferro-concrete sheet piling, which has never been tried might probably be used. Of the second method there have been several good examples in Scotland, but the principle has reached its greatest development in Germany. The freezing process, which was devised in 1883, has been used repeatedly with success in France and Germany. In Great Britain it has recently been applied in the Durham coal fields at Washington, at Eastington, at Dawdon, and is now in progress at the famous Wearmouth collieries. Finally, reference was made to a method that has been tried in France, the forcing of cement slurry through bore-holes into soft, fissured strata, in order to form a wall of concrete within which sinking can be performed.

Mr. C. E. Rhodes' paper on "The Design and Equipment of Shafts for Deep Winding" was interesting chiefly on the mechanical side.

Mr. E. H. Mann's paper on "Arrangement and Design of Colliery Surface Works" need only be mentioned, because of its account of the use of coke ovens with the employment of gas for driving gas engines coupled to electric generators.

A paper by Mr J. E. Stead on "Segregation in Steel," both in its contents and in the speakers who discussed the paper, suggested a meeting of the Iron and Steel Institute. Mr. Stead commenced with the following universally accepted views:

"1. That the purer crystallites fall out of solution in advance, leaving a less pure metal liquid and that at one stage of the gradual solidification the metal is a pasty mass consisting of the purer solid part and an impure liquid portion.

"2. That from some cause or causes some of the more impure liquid is rejected from the surface of the freezing walls in ingots. This ascends and finally lodges under the solid upper crust of the ingots, where it eventually freezes.

"3. That steel which is wild after pouring into the mould is usually badly segregated.

"4. That steel cast at abnormally high temperatures, or what is equivalent, very slowly cooled, favors axial segregation of the impurities.

"5. That the addition of a small quantity of aluminium to liquid steel, which is practiced by steel makers for the purpose of producing quietness in the mould and soundness in the steel, also reduces axial segregation, a fact admirably demonstrated by Mr. Benjamin Talbot.

"6. That not only does aluminium effect the reduction of axial segregation, but, as is proved by the microstructures of the specimens exhibited, it also almost completely removes the minor or dark spot segregations.

"7. That sulphur segregates the most, whilst phosphorus is intermediate between sulphur and carbon in this respect."

Upon these facts the following hypothetical conclusions were presented:

"1. That as the segregate rejected from the freezing steel is specifically lighter than the liquid steel it will, on that account, float upwards along the freezing walls of the ingot.

"2. That the gases driven off from the freezing walls must accelerate the ascent of the segregate, and therefore anything which will reduce or prevent the elimination of gas must tend to check the rate at which the more impure liquid ascends.

"3. That gas blow-holes, which can only form in the plastic mixture of solid pure crystallites and impure liquid, must exert considerable pressure on the pasty metal, and it seems almost certain that some of the impure liquid will be squeezed out, escape into, and join the liquid adjoining the freezing walls, and, therefore, under certain conditions, the formation of blow-holes must increase axial segregation.

"4 That because the segregate rises to the top of the still fluid column, there must be a central descending slow current. This current in passing over the very slowly freezing lower part of the ingot, deposits the purer crystallites. The impurer liquid then flows horizontally to the vertical walls and ascends, but as the walls develop and grow out of the liquid facing them, solid layers must be formed richer in impurities than the average steel. In this way I explain the annular rings, or fringes, and the purer metal in the lower central axes.

"5. The rings of independent dark spots are accounted for by the assumption that some of the gas in the blow-holes, after exerting its pressure, escapes, and that a portion of the impure liquid enters and more or less completely fills them. That some of the holes have been found lined with impurer metal is a fact.

"6. The irregularly distributed dark spots may be due to the same cause as is suggested in the last paragraph, and also to the land-locking of the segregate between the branches of the large primary crystals."

In conclusion, Mr. Stead pointed out the difficulty of diagnosing cases of segregation. Very frequently rail failures attributed to sulphur, phosphorus or manganese were due solely to bad laying.

A large number of speakers took part in the discussion, which was opened by Mr. George Ritchie, who agreed with the author in thinking that the segregation was less in sound ingots than in honeycombed ones. The difficulty of securing sound ingots increased with the size of the ingot, and in illustration of his remarks he showed a photograph of a longitudinal section through the center of a huge 20.15-ton fluid compressor ingot made at Beardmore's Parkhead Forge. Mr. Archhutt referred to the effect of segregation in causing discrepancies in analysis. He cited the case of a piece of a rail drilled in twelve places, different analytical results being obtained in each case. Mr. F. W. Harbord disagreed with the author in some of his views. Provided that the temperature of casting is kept under control, segregation was not a serious matter in the case of the highest qualities of steel. Mr. C. P. Sandberg, Jr., considered that, for rails, porosity was a greater danger than segregation. For a complete study of segregation it was necessary to deal with the question from a chemical and physical point of view.

Mr. Stead replied briefly, confessing that the statement that aluminium removes the dark spot segregations, whilst regarded as an acknowledged fact by himself, was not so regarded by everybody. He felt that there was still much ignorance with regard to segregation, and that further research was necessary, which might advantageously be conducted on the lines indicated by Sir Thomas Wrightson.

A joint meeting of the "Mining and Metallurgical Section" and Section VII., "Applications of Electricity," was next held, to listen to Mr. Bertram Blount, *Optimist*, upon "Electrometallurgy." Mr. Blount's optimism was simply superlative. Not content with describing what had been done in regard to copper refining, he forecasted an electric furnace capable of smelting copper ores. Improvements in the manufacture of aluminium would probably lower the cost and permit its use as freely as zinc. "The largest of all electro-metallurgical industries will be the manufacture of steel. Already steels of high grade can be successfully prepared in electric furnaces of various types—the Héroult and the Kjellin representing two of the most distinctive and promising. Probably, in the first instance, the electrical method will have its greatest measure of success in preparing steels of such high grade that any extra cost will be quite outweighed by the certainty that the metal will absorb no impurity in the course of manufacture. But as methods are cheapened it may well be that every grade of steel now prepared in open-hearth furnaces will be prepared in corresponding furnaces electrically heated. The power

necessary should be obtainable from blast furnace gases, for, after a liberal allowance for heating the blast and for the blowing engines, hoists and subsidiary gear, there is certainly an ample surplus, provided modern power plant is installed. Zinc is a metal not at present smelted electrically, but which for chemical and physical reasons is excellently fitted for production in that manner. There is much the same reason to replace the present furnaces with their numberless small and costly retorts by a furnace internally heated by current, as there was to supersede the older mode of making phosphorus and carbon bisulphide by the electrical methods now in operation.

Of contributions to the discussion only a few need be noted. Mr. McLaren pointed out the important difference which exists between iron and steel smelting to copper smelting; the valuable product in the former case is large, while in the latter it is small. He also called attention to the fact that copper at high temperatures is subject to a certain loss in value.

Prof. Harbord said that the electric furnace was not a competitor of the blast furnace as regards cost. The electric furnace was not a cheap melter but a cheap refiner. He advocated starting with the blast furnace and refining with the electric furnace. He was of opinion that blast furnace gases were of little value for power purposes. In his opinion the value of water power was very much exaggerated; as a rule water power was too intermittent to be of much commercial value. There were, of course, a few exceptional cases, such as Niagara.

Mr. A. A. Campbell Swinton said the subject should be of interest to all electrical engineers wishing to improve their load factors. He mentioned that the Carville power station at Newcastle-on-Tyne was already supplying a considerable load to a neighboring aluminium company, and that the British Aluminium Co. was about to take power from the same station. It would, he thought, pay to supply current at a very low price, as it would have a great effect on the standing charges. An electric furnace was understood to mean heat produced by an electric arc, but Sir William Crookes had shown that the bombardment of cathode rays within a vacuum tube generated intense heat. In a lecture which he, Mr. Swinton, had delivered before a kindred institution, he had shown that this could be employed on a large scale, and he was pleased to hear that Messrs. Siemens Bros. were using the device in connection with the manufacture of electric lamp filaments.

Dr. F. M. Perkin said that the paper did not cover the whole of the electro-metallurgical industries; graphite, calcium carbide and carborundum had, for instance, been omitted. He was aware, however, that its limited length would not allow of everything being dealt with. One reason why so much of the electro-metallurgy work had gone abroad was that engineers and chemists in this country had not worked together. He was interested in the cathode rays system mentioned by Mr. Swinton. He could believe that the system would be successful on a small scale for dealing with tantalum, but the difficulty in adopting the system on a large scale appeared to lie in maintaining a good vacuum.

A paper upon "The Education of Engineering Students Particularly with Regard to Mining and Metallurgy," by Mr Walter Rowley, concluded the work of this section.

Shipbuilding.

The dependence of the shipbuilder upon the metallurgist and the value of steel of high tensile strength, formed the subject matter of three papers presented jointly to the Shipbuilding Section and to the Mining and Metallurgical Section

Mr. A. E. Seaton presented a paper entitled "The Use of High Tensile Steel in Compound Structures, Such as Ships, Bridges, Etc." In 1872, Whitworth offered steel plates of 40 tons per square inch tensile strength and 30 per cent elongation. In 1874-5 Siemens offered 40-ton plates to the Admiralty, which were tough and good. In 1878 merchant ships were being classed which were built of iron whose utmost strength was 22 tons per square inch and elongation seldom more than 3 per cent, and warships built of iron of 23 tons strength with 5 per cent elongation. Steelmakers then offered a material 20 per cent stronger, with an elongation of 20 per cent, and to bend double when cold instead of snapping after a few degrees, as the iron did. The first bridge to benefit by steel was built by Eads at St. Louis in 1874; the first wholly of steel was the Glasgow Bridge over the Missouri River in 1879.

Since 1896 high-tensile steel has been successfully employed in the construction of destroyers and similar craft. In the Forth Bridge it was used only in compression; to-day there need be no hesitation to put it into tension, and overcome thereby many difficulties. Recently the huge Cunard ships, with their heavy machinery, have been constructed to withstand the stresses of service conditions by freely using the high-tensile steel of Spencer and Colville.

The author was firmly of opinion that high-tensile steel could be used with advantage in spite of its higher price and allegations as to extra cost of working. Upon the latter subject Mr. Seaton declared that this should be little or nothing, for even if it were necessary to drill and plane, instead of punch and shear, with modern tools and special steel it could be done as cheaply. Then this steel could be handled hot or cold just as the mildest steel. The angle-bars of keelsons, stringers and other longitudinals might be of it, as also the angle-bars of deep frames and other analogous stiffeners. The rivets should be of it, or of a steel whose resistance to shear is more than 20 tons, if the utmost advantage is required. Tough high tensile strength steel might be used in place of steel casting.

Mr. A. F. Yarrow contributed the second paper, dealing with "High-Tensile Steel for Torpedoboat Construction." This described the experiences his firm had had in constructing the destroyer "Sokol," in 1894, for the Russian government. The metal used in the hull had a tensile strength of 37 tons to 44 tons per square inch, and an extension of not less than 15 per cent in 8 inches for plates of 3/16 inch thick and over. "I take it," said the author, "our aim should be that all parts of the same structure should offer the maximum resistance simultaneously, and by so doing secure collectively a greater resistance to distortion than if the giving way were at varying periods. I think also the frames should be of high tensile steel, because they would be stiffer to resist distortion. With regard to the riveting of the high-tensile steel plates, in the "Sokol" we increased the rivet area from what we adopted previously to the extent of about 50 per cent. This was arrived at by careful experiment; it was found that the high-tensile steel plates would shear the rivets if there were not a very large margin beyond the usual practice in rivet area—that is, assuming mild steel rivets were used in combination with high-tensile steel plates. The advantage gained by using this class of steel was considerable."

The third paper, by Mr. E. W. de Rissett, upon "The Use of High-Tensile Steel in the Construction of the 'Mauretania'" stated that at a very early stage, when the stresses and structural strength of this vast and heavily-powered vessel were being considered, it became evident that steel of superior strength, in conjunction with hydraulic riveting, would have to be employed at certain parts to produce a structure which would combine the maximum of strength with the minimum of weight. It was then determined by the builders of the "Mauretania" and sister vessel "Lusitania," in conjunction with the Cunard Co. and the officials at the Admiralty and Lloyds, that high-tensile steel should be employed where the greatest stresses would be encountered, and also in other parts of the structure where steel of this character could be profitably employed to save weight, such steel to have the following qualifications under normal conditions. (1) An ultimate tensile strength of 34 to 38 tons per square inch; (2) an elastic limit of not less than 20 tons per square inch; (3) elongation not less than 20 per cent in 8 inches. In addition it should satisfactorily stand certain physical tests. For plates

¾ inch thick and less it was found that high-carbon steel fulfilled these conditions, but for greater thicknesses silicon steel, supplied by Messrs. J. Spencer & Sons, Newburn, was preferred, as the high-carbon steel of 34 to 38 tons tensile strength proved slightly defective in the elastic limit. During mechanical tests made by Lloyds of the pieces of high-carbon steel in which a single rivet hole had been made, it was observed that to punch the hole ⅛ inch small and rimer it out to full size reduced the strength of the sample less than if the hole had been drilled the full size. At all events they consider they were quite warranted in the face of such evidence in punching the high-tensile steel plates up to ½ inch in thickness with holes ⅛ inch less in diameter, then rimering them out to the full diameter required by the rivet. By punching the holes small and rimering them as described, the saving in labor was about 10s. per plate, or about 30 per cent less than electric drilling. All the holes in high-tensile steel above ½ inch in thickness were drilled, and the rag of the hole was removed by a special tool, which at the same time removed the sharp edge of the hole and produced the requisite taper for the neck of the rivet. High-carbon steel was adopted in all the main transverse and longitudinal bulkheads extending to the upper deck. The lower portions of these are 10/20 inch thick, thence 9/20 inch to lower deck, 7/20 inch to main deck, and above this they are 6/20 inch. The stiffening bars are of ordinary mild steel of channel or angle sections. Silicon steel was used for parts of the top sides and doublings, also for the stringers, decks and doublings on the shelter deck for the full width between the ship's side and casings, and stringer and adjoining strake on upper deck for a width of 8 feet 6 inches, and for a length of about 500 feet amidships on the shelter deck, and about 480 feet on the upper deck, tapering off at the ends. The remainder of the plating to the sides of the casings on the upper deck is of high-tensile carbon steel extending for 400 feet in length. By the employment of high-tensile steel a reduction of 10 per cent on the basis of scantlings of mild steel was allowed, and a corresponding reduction in the thickness of the bulkheads were made of this material. The result had been a saving in weight of about 200 tons with an appreciable increase of strength in the top structure. The silicon and high-carbon steel were not annealed. The edges of seams and butts were planed. The author also pointed out how, in his opinion, a reduction of a further 10 per cent—making 20 per cent in all—might have been made in these vessels. The authorities at Lloyds Registry, from their experience up to date, strongly recommended that the rivets used for the whole structure, including the silicon and high-carbon steel, should be made of mild ingot steel, consequently this material was adopted, special provision being made to minimize the shearing effect on them by rounding the edges of the drilled holes by a special tool, which was also coned to suit the taper neck of the rivet.

The Faraday Society.

The June meeting of this Society, with its four papers and general discussion on "Hydrates in Solution," was only mentioned in my last letter. The papers were as follows:

(1) By Mr. W. R. Bousfield and Dr. T. M. Lowry on "Thermochemistry of Electrolytes"; (2) by Dr. J. C. Philip, on "Hydrates in Solution"; (3) by Dr. G. Senter, on "Methods for Determining the Degree of Hydration"; and (4) by Dr. A. Findlay, on "The Stability of Hydrates."

The discussion was relatively brief. Prof. W. A. Tilden, F. R. S., referred to the fact that in crystals it appeared to be the metal only which detained the water of crystallization. In many cases such as that of ammonia dissolved in water, where ammonia as such was also present, the hydrate theory could not be adopted as it stood. There was, in fact, no single theory at present able to explain all the phenomena observed.

Mr. Caldwell criticised the various methods used for measuring hydration. In the experiments of Jones, for example, whose method was open to objection, many of the results did not follow what would be expected from the law of mass action. Philip assumed that the dissolution of a gas was mechanical and that of a salt chemical. If that were true, a gas of small molecular weight, such as helium, should be really soluble.

Mr. W. A. Davis said that there were many cases of solution —*e. g.*, in dyeing—which were covered by neither the ionic nor the hydration theory, but in which the process was purely mechanical.

Mr. Fenton said that it was not always very clear what was meant by hydrate. The methods hitherto employed for studying hydrates were chiefly physical, and the results obtained were capable of many interpretations. The problem should be studied in such a way that specific chemical properties were obtained.

In reply to Dr. H. Borns, Dr. Lowry said he imagined ionization to be the result of the separate hydration of the ionic constituents of the molecule.

The chairman (Prof. Pickering) thought that the agreement between the heat of formation of a salt in dilute solution and the sum of the separate heats of formation of the ions shown to exist by Mr. Bousfield and Dr. Lowry proved nothing, as the proof involved reasoning in a circle.

In reply, the authors explained that the agreement proved these properties of the ions to be additive, and so gave further support to the dissociation hypothesis.

London, Aug. 3, 1907.

Market Report for July.

Chemicals have still a downward tendency. Copper sulphate has dropped to £31 from £32 at the end of June. Ammonia sulphate is quoted £11.17.6, as against £12.10. Montreal potash is at £40 per ton. Bleaching powder 2s. 6d. lower at £4.10, and caustic soda (77 per cent) unchanged at £10.12.6. Zinc sulphate steady at £8. Copper has continued falling throughout the month. The end of June saw the price at £96.10, the 15th July showed £94.10, and the 29th £90. Three months' deliveries could be had at £86 at the month end, and the price has since weakened further. Tin continued to rise until the commencement of the second week in July, when £200 per ton was again paid. Fresh supplies dropped the price to £180 by the 15th. The market remained quiet during the closing week, £184 being the closing price.

Lead has receded to £20.16. Cleveland pig shows firmer at 57s. Hematites has risen to 78s. Antimony is quoted £43 to £45, a decided falling off.

Calcium Cyanamide Industry.—From the London *Electrical Review* of July 19 we gather the following notes on new calcium cyanamide plants in Europe. The Brandenburgische Carbidwerk G. m. b. H. has obtained a license for Germany and Norway, and is able to make about 2,500 tons per annum at its factory in Mühlthal (Bromberg), handing 5 per cent of the net profit to the Roman Co., which is the holding company of the cyanamide patents. A works is being built at Odde, in Norway, near the Alby United Carbide Factories, where some 12,500 tons of calcium cyanamide are to be made from 10,000 tons of calcium carbide, the latter being procured from the Alby factories. The Soc. Italiana Prodotti Azotati has obtained a license for Austria-Hungary, and is about to erect a second works, while the factory of the Societa per l'Utilizzazione delle forze Idrauliche della Dalmazia, which is already in existence there, has an annual capacity of about 10,000 tons. We have already noted that in this country the American Cyanamid Co. intends to erect a plant with an initial capacity of 20,000 tons per year at Muscle Shoals on the Tennessee River, in Northern Alabama. The trade name for calcium cyanamide will be lime nitrogen, which is the literal translation of the German Kalkstickotoff.

SYNOPSIS OF PERIODICAL LITERATURE

A Summary of Articles Appearing in American and Foreign Periodicals.

Industrial Electrochemistry.

Electrolytic Rectifier.—The property of an aluminium electrode to permit an electric current to pass in one direction but not in the other direction has been used for the construction of electrolytic rectifiers and condensers, as has been repeatedly described and noticed in this journal. G. Schultze in a paper published in *Ann. d. Phys.*, No. 7, and abstracted in London *Electrical Engineering*, July 18, has found that tantalum is even superior to aluminium for electrolytic valve effects. There is no electrolyte in which tantalum fails to show a valve effect. The voltage which the non-conducting layer deposited on the anode is capable of resisting is also much higher, being over 650 in carbonate of soda, 600 in various fluorides, and 70 in concentrated caustic potash. It is best to have the tantalum electrode entirely immersed, as otherwise sparks may pass from the surface of the liquid to the emergent portion. Such sparks show the tantalum spectrum, whereas sparks through the liquid show nothing but the spectrum of the electrolyte. The anode skin is easily formed in the course of a few minutes, and is not much affected by heat. Herein it has a great advantage over aluminium. But this is to some extent balanced by the instability of the skin on tantalum electrodes, which is greatly reduced in efficiency in the course of a few minutes' break of the current. Niobium and vanadium also show a valve effect in all electrolytes, though it does not approach 1,000 volts, as in tantalum. Other metals, like Cu in copper sulphate, show a slight action of this kind, but it is not of any practical utility.

Electrolytic Lightning Arrester.—While the electrolytic rectifier has one aluminium electrode, the electrolytic condenser has two aluminium electrodes. As long as the voltage is below the critical valve, neither a direct current nor an alternating current is able to pass. For this reason the electrolytic condenser is very suitable as a lightning arrester. To use it on circuits of 4,000 to 60,000 volts, it is of course necessary to use a number of such cells in series. R. P. Jackson, in the August issue of *The Electric Journal*, describes how this is done by assembling them in tray form so that one may rest within another, insulated from each other, but all containing the electrolyte. The electrolytic ligtning arrester is preferably used in conjunction with a horn ligtning arrester.

Calcium Nitrate as Fertilizer.—Calcium nitrate is the form of artificial fertilizer produced from nitric acid at the works using the Birkeland-Eyde process in Norway. An improvement mentioned in London *Electrical Review*, Aug. 9, due to E. Kollett and the Det. Norske Akt. for Elektrokemisk Industri of Kristiania, has the advantage that their new fertilizing product contains more nitrogen and is not hygroscopic. The calcium nitrate is mixed with a proper quantity, *i. e.*, about 40 per cent of ammonium sulphate, by mixing them together either in the state of powder or by melting the calcium nitrate. The product is a double salt, or a mixture of calcium sulphate and ammonium nitrate, which is stated to have the properties above mentioned. If the original calcium nitrate contains an excess of any base, it is advisable to add a corresponding quantity of superphosphate, or some other material having an acid reaction.

Tin.—In *L'Eclairage Electrique* of July 20, J. Reyval describes an electrolytic process for recovering tin which is stated to be in commercial use, the French patent being No. 364,589, of March 26, 1906. The tin is obtained not in spongy form but in thick plates from scrap of tin, scrap of tinned iron plates, etc. In the installation in which the process is in use, it is, however, applied to the treatment of the slimes which result from the winning of copper from copper-tin bronze by treatment with sulphuric acid. But it is stated that the process is equally applicable to natural ores after they have undergone an oxidizing roast and leaching. When slimes resulting from bronze are treated almost the whole tin is in the form of stannous hydrate which is to be changed into stannic hydrate, this offers no difficulties.

The first step of the process is the production of a solution of sodium stannate. The tin hydroxide is treated at boiling point with a caustic soda lye of 10 or 12 per cent in iron receptacles. A liter of a 12 per cent caustic soda solution dissolves 45 to 50 grams of tin. At the beginning of operation a freshly-made-up caustic soda solution is used, but later on the solution which has already been subjected to electrolysis and which contains a certain amount of sodium stannate is utilized, the necessary amount of stannic hydrate being added. If the process is not to be applied to the hydroxides of tin but to oxides, etc., the formation of the stannate is more difficult, although it can be facilitated by the addition of sodium nitrate.

The second step of the process is the purification of the sodium stannate solution. Copper and lead are the most dangerous impurities. For purification a very concentrated solution of sodium sulphide is employed at a temperature of 70 degrees C. Rapid stirring is necessary.

The third step consists of the electrolysis of the sodium stannate. This is carried out in iron receptacles with iron anodes at a temperature of 90 degrees C. The voltage is 2.4 and the cathodic current density 300 to 400 amperes per square meter, one single face of the cathode being counted. The cathodes may consist of tin foil or of tinned iron sheets. It is easy to connect 30 cells in series. Insulation difficulties arise when the total voltage is beyond 80. It is of greatest importance that the temperature should never fall below 80 degrees C.; that excessive current density should be avoided; that the electrolyte should contain sufficient sodium stannate; that the electrolyte should be strongly stirred or circulated, and that insoluble anodes are employed. The solution should always contain not less than 10 grams of tin per liter in order to get good deposits. To make up for evaporation, water is added from time to time. The deposit obtained by this process is stated to be excellent. The amount of tin obtained in practice per ampere hour is 0.8 gram when the current density is not too high. The electrolytic reaction is given in the form $SnO_2Na_2 = Sn + Na_2O_2$. At the anode the anions Na_2O_2, in presence of water give sodium hydroxide and oxygen according to the equation $Na_2O_2 + H_2O = 2(NaOH) + 2O$. If the electrolyte gets poor in sodium stannate it becomes rich in sodium hydroxide and then the electrolysis yields practically oxygen at the anode and hydrogen at the cathode. For this reason it is necessary to keep the strength of the electrolyte at the proper figure.

Manufacture of Chlorates.—In *L'Eclairage Electrique*, of July 27, G. Rosset begins what promises to become a long article on the manufacture of chlorates. He first gives an historical review of the manufacture of matches and an outline of processes for making chlorates from chlorine and caustic as starting materials which may or may not have been made electrolytically. He then gives a summary of the physical and chemical properties of potassium chlorate, sodium chlorate and barium chlorate.

Induction Furnace.—In London *Electrical Engineering*, July 18, we notice a patent of de Ferranti for induction furnaces in which the primaries consist of water-cooled tubes and means are provided for preventing the iron cores from reaching a temperature above that of maximum permeability. The new features appear to be that a rotary field may be arranged to circulate or mix the molten metal and that "the whole furnace is lagged with molded quartz."

Iron in the Electric Furnace.—The London *Electrical Review* of July 19 gives the following note on experiments car-

ried out recently by A. Hiorth in the new electrochemical institute of the Technical High School at Christiania. They are said to have shown that a good quality of metal can be obtained by electrically smelting a low grade of iron ore, unfit for reduction in the blast furnace, together with impure Norwegian graphite. The original iron-sand contains about 13 per cent of titanic acid and 20 per cent of silica, whereas the finished metal contains not a trace of titanium and only 0.01 per cent of silica. The graphite employed occurs in many parts of Norway in beds 30 to 60 feet thick.

Porous Diaphragms of Wood.—In London *Electrical Review* of July 19 it is stated that Q. Marino and E. W. Barton-Wright have taken out a French patent for a process to convert wood into a porous diaphragm fit for employment in electrolytic cells, and one which confers upon the material a high resistance to the corroding action of electrolytes. The process consists in treating wood for 8 to 10 hours with cuprammonium oxide, then removing the copper by treatment with 0.88 ammonia for 5 or 6 hours, next washing the wood and soaking it in crude nitric acid for from 2 to 4 hours (which converts the gummy material into a yellow resin) and finally exposing it to a blast of steam and sulphur dioxide for 5 to 15 minutes. The last operation results in the formation of a mixture of nitric and sulphuric acid, which converts the cellulose into nitro-cellulose and allows the latter to be dissolved out of the material with the aid of alcoholic caustic potash and ethyl acetate. The product is stated to possess a considerable amount of malleability.

Lead.

The Roast-Reaction Process.—R. Schenck and W. Rassbach give in *Metallurgie* for July 8 a splendid study of the reactions of this process, undertaken experimentally with the guidance of the phase rule. The well-known reactions are formulated as:

$$PbS + PbSO^4 = 2Pb + 2SO^2.$$
$$PbS + 2PbO = 3Pb + SO^2.$$

In the Huntington-Heberlein process the following reaction has been brought into use:

$$PbS + 3PbSO^4 = 4PbO + 4SO^2.$$

To complete the study, it is seen by applying the principles of the phase rule that one other reaction should be investigated, viz.:

$$PbS + PbSO^4 = 2PbO + SO^2.$$

These four reactions contain all possible chemical changes of these substances.

The first reaction given above was found to be reversible and to lead to an equilibrium; the following being the reaction tensions of the SO^2:

600° C.	30	m.m. Hg.
650° C.	143	" "
700° C.	442	" "
725° C.	735	" "

The activity of the reaction varies very considerably in a small range of temperature, and at any temperature within this range is dominated very strongly by the partial pressure of the SO^2.

The second reaction was also found reversible with equilibrium under the following conditions of SO^2 tension:

700° C.	10	m.m. Hg.
750° C.	35	" "
800° C.	99	" "
825° C.	286	" "
850° C.	550	" "
875° C.	850	" "

This second reaction takes practically 150° higher temperature to make it go than the first. At 800° PbS showed signs of volatilizing, and at higher temperatures vaporized rapidly. Also, the metallic lead formed in these reactions can dissolve PbS in the melted state, and this solubility interferes or disturbs the normal course of the reactions to some extent.

The third reaction possesses no equilibrium temperature up to pressures of SO^2 of one atmosphere; it is possible, however, that such occurs for higher pressures. As it is, from 550° on the reaction proceeds irreversibly. The same is true of the fourth reaction.

In roasting PbS the concentration of the SO^2 has a great influence on the product; from 600° and pressure of 30 m.m. to 720° and pressure of 760 m.m., $PbSO^4$ tends to form; at lower tensions of SO^2 at these temperatures PbO forms; from 700° at tensions of SO^2 below 100 m.m. Pb forms, and above 880° Pb forms with any tensions of SO^2. The investigation throws much needed light upon the oldest and most-used reactions in the metallurgy of lead.

Iron and Steel.

Basic Bessemer Converters.—M. Belman has made some observations on the rate of cooling of the interior of a basic converter which may give some idea of the radiation losses during the Bessemer blow. He found the temperature of the lining at the hottest visible point as follows:

On stopping the blast	1,550° C.
One minute later	1,450° C.
Converter empty	1,350° C.
5 minutes after emptying	1,250° C.
10 minutes after emptying	1,200° C.
20 minutes after emptying	1,150° C.
35 minutes after emptying	1,100° C.

The observations would have been much more complete and serviceable if the temperatures of the outside shell had also been found, the temperature and velocity of the surrounding air, the approximate weight and constitution of the converter, so as to allow of calculating the actual heat units lost by the cooling. (*Revue de Metallurgie*, July.)

Steel Works Machinery.—We cannot do less than recommend most strongly to all our readers interested in handling heavy weights, fluid metal, charging furnaces and casting ingots, the perusal of Dr. G. Stauber's fine monograph of 85 pages, illustrated by 153 cuts, in *Stahl und Eisen* for July 10. It is a complete presentation of the most recent information on this subject.

Coke.

Coking of Coals.—In his presidential address before the Coal Mining Institute of America, F. C. Keighley discussed the question why some coals coke and others do not. The finest coking coals are of the bituminous class and their structure is such that upon fracture they exhibit a fingery or prismatic form and separate vertically, while the coals more difficult to coke and the ones of a bituminous character that cannot be coked at all are of a laminated structure and upon fracture break into cubical form, with a tendency to separate horizontally instead of vertically. This would indicate that the coking property depends very largely upon the "arrangement of the atoms or molecules composing the coal seam. If these atoms lie in the seam with their longer axis horizontal to the bedding of the seam, they are unfavorable to the coking process. On the other hand, if they are perpendicular to the strike of the seam, *i. e.*, at right angles with its bedding, the coking tendency is much pronounced. It is likely that in all seams the longer axes of the atoms are lying at angles to the horizontal or the vertical. This would explain some of the mystery." Coke is being made to-day from coal that ten years ago was rejected as worthless for the purpose. Many people were attracted to such coals by the similarity of their chemical constituents to the Connellsville coking coal; yet while they would coke, the coke was unsuitable for the requirements of the consumer. Some of these coals were laminated in structure and others tended to the crystalline, and it has been

proved now that all that was required to make many of these condensed coals produce a fine grade of coking coal was simply to break them up to a greater or less degree of fineness and destroy, at is were, the natural polarity of the atoms making up the coal seam. This was accomplished in various ways, namely, by crushing, disintegrating and pulverizing. It is evident, then, that the coking principle of coal is dependent to an important extent on its structure. In the author's conclusions it is said that the reason for some coals coking or submitting themselves naturally and readily to the coking process and furnishing a high grade coke are as follows:

1. They are in structure largely prismoidal, permitting the free mixing of the particles, diffusion of gases, etc.

2. Their chemical composition is such that they contain not only the fusing and cementing factors in the most favorable proportions, but they carry the most desirable elements in those proportions and the form best adapted to the purpose for which the coke is required.

The reason some coals are not naturally fitted for the coking process, but yield high-grade coke after disintegration, are as follows:

1. Their structure is largely of a laminated character, thus presenting obstacles to the free mixing of the particles and diffusion of gases.

2. Their chemical composition is not widely different from those of the natural coking coals, but they cannot adjust themselves to the necessary processes of fusion, cementation and interchange of position of the different elements the complete coking process requires, unless the coal has first been disintegrated or pulverized.

ANALYSIS OF CURRENT ELECTRO CHEMICAL PATENTS.

Electric Furnaces.

Reduction of Oxide Ores in Electric Furnace.—A. J. Petersson, 858,621 and 858,622, July 2, 1907. Application filed Oct. 30, 1906.

The principal object of these two patents and of the one analyzed in the next abstract is to utilize to the fullest extent the calorific value of the fuel in the furnace. Fig. 1 shows a vertical and a horizontal section of the electric furnace. There are three shafts, 1, 2 and 3, of which 1 and 3 are charged with ore and 2 with coal, anthracite, etc., or the like. The lower parts of the shafts are in open communication with each other, but, nevertheless, the carbon and the ore also here form separate layers or columns, the columns of ore closely surrounding the column of carbon. The carbon column constitutes the reduction and melting zone proper. Current is introduced into the furnace through the electrodes 7, 8, which are in contact with the carbon column in the furnace. When the furnace has been charged about to the height indicated in the upper diagram, the lower part of the carbon is heated to incandescence by turning the current on. The ventilator 21 is then put in operation, and a current of air is circulated in the direction of the arrow. When the air passes through the column of incandescent carbon it is burned to CO and at the same time intensely heated. In then passing through the column of ore below shaft 1, this ore is reduced by the CO with production of CO_2. The mixture of CO_2 and air then passes through the channels 16 into the regenerator 18, where it gives off its heat. The gas mixture then passes through the pipe 20 and the ventilator 21 in a comparatively cold condition, whereby losses of heat and injuries on the ventilator are obviated. The gases then again enter the system, and this circulation is carried out continually, the result being that the gas is successively converted into CO within the carbon of the charge and reoxidized to CO_2 by the ore. The excess of gas flows off through the shafts 1 and 3 and the outlets 22 and 23. Simultaneously, heat is transferred by the circulating gas to the column of ore below the shaft 1 and to the regenerator 18, which absorbs the remaining heat of the gas. By this transfer of heat and by direct conduction of heat the reduced metal melts and drops down into the reservoir 9. In order to keep it molten this reservoir is carried out in form of an annular trough, which is heated on the principle of an induction furnace, a transformer core 15 with a suitable primary coil 14 being provided for this purpose.

When the desired quantity of heat has been stored up in the regenerator 18 the ventilator is reversed so that the gas

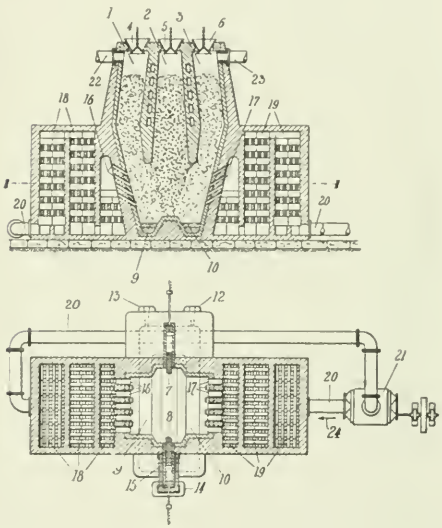


FIG. 1.—ELECTRIC FURNACE.

will circulate in opposite direction. The regenerator 18 is now cooling down and the regenerator 19 is heating up. When this has been done to a sufficient degree the direction of the circulation of the gases is again reversed and this reversal is repeated as often as suitable. Eventually the direction of the reversal of the flow of the gases may be made at so short intervals that the mass of gas partaking in the reaction will oscillate in the column of carbon and the column of ore on each side thereof. The central column of carbon, which is electrically heated, reduces the CO_2 formed in the reduction of the ore, and thus yields new CO for reducing the column of ore on the other side. The object of the regenerators is to prevent losses of heat otherwise caused by the heat being moved by means of the circulating gases.

When volatile ores such as zinc are to be reduced a column of carbon may suitably be arranged on each side of the column of ore. The mixture of metal vapor and carbonic acid formed in the reduction of the ore will then always—independently of the direction of circulation—pass through a column of carbon heated to incandescence, so that the CO_2 is fully reduced to CO, and no CO_2 is mixed with the zinc vapor which could oxidize it again.

In 858,622 the same process is described, but emphasis is laid on the fact that the excess of carbonic oxide formed in the reduction process is utilized for the preluminary heating of the charge.

Calcium Carbide Process.—A. J. Petersson, 858,623, July 2, 1907. Application filed Oct. 13, 1906.

The principle is the same as that described in the preceding abstract. Fig. 2 shows an electric furnace specially adapted for the manufacture of calcium carbide. 1 and 2 are the two

electrodes. The carbon is introduced so as to form a column around the two electrodes, while the lime is introduced at both sides of the carbon column, so as to fill the space between the latter and the walls of the furnace. The current passes mainly through the carbon column and heats it so as to cause its reaction with lime at the contact surface, thereby forming CO gas and calcium carbide, which melts and accumulates at the bottom of the furnace. Air is drawn through the suction fan 6 so as to pass through the charge downwards and through holes in the walls into the annular channel 3. When the air comes in contact with the CO gases the latter burn and develop an intense heat in the outer part of the lime layers, which are thus intensely preheated before entering the reaction zones of the furnace.

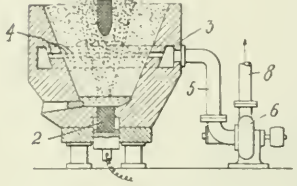


FIG. 2.—CARBIDE FURNACE.

Calcium Carbide Furnace.—A. J. Petersson, 863,044, Aug. 13, 1907. Application filed Oct. 30, 1906.

While the usual practice in the manufacture of calcium carbide is to charge into the electric furnace a mixture of crushed lime and carbon, this has the disadvantage that those particles of lime which come into contact with the carbon electrodes enter into chemical reaction with the latter so that the electrodes furnish carbon for the production of calcium carbide. This is not desirable, since the electrodes are far more expensive than the carbon in the charge. The present inventor proposes to charge the lime and carbon separately in such a way that the carbon alone comes in contact with the electrode. The current then passes principally through the carbon layer, and since the arrangement may be made that the charge of carbon is in the center of the furnace good heat insulation is provided. The layer of lime in contact with the carbon is reduced, forming carbonic oxide, which passes off, and calcium carbide, which melts and may be drawn off at suitable intervals.

FIG. 3.—JOINT FOR ELECTRODES.

Joint for Carbon Electrodes.—F. J. Tone, 863,074, Aug. 20, 1907. Application filed Sept. 25, 1906.

Since graphite electrodes have come into use for electric furnaces it has become customary when it is desired to assemble two or more pieces to thread one piece into another. In this way a new electrode can be joined to the end of one in use, and thus electrodes can be fed into the furnace one after another without interruption. In order to produce a joint of high conductivity and good mechanical strength the inventor uses a tapered threaded joint such as shown in Fig. 3, where 2 and 3 are the carbon electrode pieces to be joined. The ends of the two pieces are provided with a tapered threaded portion and a tapered threaded socket, respectively.

Manufacture of Phosphorus in the Electric Furnace.—G. C. Landis, 859,086, July 2, 1907. Application filed April 9, 1907. Assigned to American Phosphorus Co.

If the charge of a phosphorus furnace is reduced to a finer powder than is usual at present the temperature in an electric phosphorus furnace, which is said to be now about 3,500° F., may be reduced to 2,700°, which is an advantage for the condensing of the phosphorus. However, if the charge consists of a very fine powder a great percentage of the dust is carried over unreduced into the condenser. This is avoided by the present inventor by briqueting the very finely divided charge before treating it in the furnace. The ingredients, such as phosphates, sand, silicate and coke are crushed, one independently of the other, and each calcined at a red heat, preferably in a rotary calcining furnace, then each ingredient is ground to about 18-mesh and the proper mixture is prepared in form of briquets. If a bond is used containing water the briquets are thoroughly dried before being put into the electric furnace. The briquets may, however, be mixed dry with a suitable bond or a bond of tar may be used.

Low-Carbon Ferro-Alloys.—E. F. Price, 862,996, Aug. 13, 1907. Application filed Nov. 14, 1905.

To produce ferro-alloys, low in carbon, by a continuous operation, the inventor uses a process in two steps. In the first step ferro-silicon, high in silicon and low in carbon, is produced by electrically smelting a charge of silica, iron ore or iron and carbon in an arc furnace. The molten silicide is then tapped from the smelting furnace and percolated through a granular body of the compound to be reduced, for instance, chromite. The silicon effects the reduction of the oxides of chromium and iron in the charge and the reduced metals alloy with the percolating iron. A basic flux, such as lime, is preferably mixed with the chromite to convert the silica produced by the reduction of oxide ores into a fusible slag. The granular mixture of chromite or other ore and lime is preferably heated by interposing the mixture as a resistance-conductor in an electric circuit, both the heated charge and the percolating metal serving to carry the electric current.

Electric Smelting of Iron Fines.—H. W. Lash, 862,978, Aug. 13, 1907. Application filed Dec. 20, 1905.

This is another patent referring to his process which was already described in our July issue, page 279, and August issue, page 322. The charge consists of iron sand or scale, finely divided cast or pig iron, coke, sawdust and fluxes, such as lime or fluorspar. A content of titanium in the iron oxide is not troublesome. The present patent refers to the proportions of the different ingredients in the mixture, and as suitable examples the three mixtures are stated, the constitution of which was already given on page 322 of our August issue.

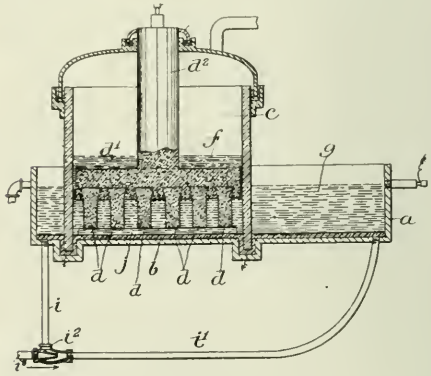


FIG. 4.—MERCURY CATHODE CELL.

Mercury Cathode Cell.—E. A. Allen, 862,783, Aug. 6, 1907. Application filed July 17, 1905. Assigned to Allen Electrochemical Co., of Rumford Falls, Me.

The sodium chloride solution f is electrolyzed in the receptacle c with a carbon anode consisting of blocks or bars d, which are dovetailed into the support d^1 and rest upon longi-

tudinal glass bars *f*. Mercury *b* in the bottom of the vessel forms the cathode. Through the mercury this inner vessel *c* is in connection with an outer vessel *a* in which caustic soda is made when the sodium amalgam formed in the inner vessel is brought to the outer vessel into contact with water. This circulation of the mercury is brought about by the pipe *i*, which contains a T-coupling *i'*. The T-coupling contains an injector so that steam introduced into the pipe *i'* forces the mercury or the amalgam to flow in the direction of the arrow. The introduction of the steam not only serves to effect the circulation, but also breaks up the amalgam largely in the pipe *i'* itself, but this reaction still continues when the amalgam reaches the water *g* in the outer tank.

Electroplating Metal Sheets.—J. Müller, 862,469, Aug. 6, 1907. Application filed April 18, 1906.

In order to coat sheets or plates by electrolysis in a continuous manner the edges of the sheets or plates are connected temporarily together so as to form a long, continuous band, and this band is then passed through the electrolyte.

Treatment of Albuminous Substances.—R. Desgeorge, 863,268, Aug. 13, 1907. Application filed Nov. 2, 1906.

The object is the treatment of certain substances having an albuminous base, for instance, casein, for obtaining non-inflammable products in imitation of horn, shell, ivory, celluloid, etc. The casein is diluted with a solution of chloride of sodium and electrolyzed between metal electrodes. If copper electrodes are used the casein assumes a clear green color after the passage of the current for some moments, owing to its reaction with copper oxide, and if the operation is prolonged the green color will become darker and darker owing to the greater absorption of oxide of copper, and the compound will become completely insoluble. If lead or aluminium electrodes are used the casein will combine with the oxide of the respective metal and become insoluble, but it will not assume any color. In this case it may be colored by aniline dyes if desired. The substance thus obtained either alone or mixed with other substances is treated to reduce it to the desired form, and may then be subjected to the action of the vapors of reducing bodies, such as formic acid, formaldehyde or solutions of such bodies.

Storage Battery.—C. Berst, 863,347, Aug. 13, 1907. Application filed April 16, 1906. Assigned to Gamewell Fire Alarm Telegraph Co.

Details of construction to prevent the escape of gases and the bubbling over of the liquid during charging. The cover of the battery is so formed as to provide a large extent of cooling surface to guide the condensed liquid back to the battery container. For this purpose the top of the battery has a "flange resting upon and projecting beyond the upper edges of the cell, the top being provided with a depending flange having concave curved sides and ends terminating in an edge extending in the direction of the length of the top."

RECENT METALLURGICAL PATENTS

Iron and Steel.

Composition of Steel.—J. W. Spencer (863,703, Aug. 20, 1907) patents a composition of steel which is stated to be specially suitable for boiler plates, ship plates and all classes of forgings such as are made from so-called mild and medium hard steel. For this purpose he adds to all kinds of mild and medium hard steels containing carbon from 0.05 up to 0.25 per cent, a larger proportion of silicon than is now used commercially for such purposes, namely, from 0.75 to 2 per cent of silicon.

Agglomerating Pulverulent Iron Ores.—In order to agglomerate magnetic concentrates or blast-furnace dust, etc., W. Schumacher (862,666, Aug. 6, 1907) briquets them with colloidal calcium silicate as a binding medium. Very finely ground quartz or flint (the finer and purer the better) is mixed with pure finely ground oxide of lime or hydrate of lime, preferably in equal parts. With this compound is then mixed, together with addition of the necessary amount of moisture, the dust or powder to be agglomerated, an admixture of about 5 per cent of the quartz-lime compound being generally sufficient. The briquets are hardened by subjecting them to the action of steam under pressure in a closed vessel.

Zinc.

Treatment of Sulphide Ores.—R. W. E. MacIvor (863,411, Aug. 13, 1907. Assigned to Metals Extraction Corporation, Ltd.) proposes the following treatment of sulphide ores containing zinc. The ore is first slowly roasted to a dull red heat under conditions which are favorable to the conversion of as much as possible of the zinc in the ore into soluble sulphate of zinc, leaving the remainder of the zinc in the ore as oxide of zinc. The roasted ore is then leached with boiling water to dissolve all the zinc sulphate, and this solution after settling is run off into tanks, where it is mixed with a solution of calcium chloride when calcium sulphate is produced and precipitated, and at the same time the chloride of zinc formed passes into solution. The latter is run off from the precipitate and is the special means for dissolving out the zinc oxide in the leached ore. For this purpose the ore is digested in the solution of zinc chloride at boiling point, whereby the chloride of zinc in solution becomes an oxychloride, approximately $ZnCl_2.3ZnO$. To this solution is added either slaked lime, carbonate of lime, magnesia or soda ash in sufficient quantity to completely decompose the zinc chloride. The precipitate of hydrate or carbonate of zinc is finally washed free from chloride. The ore after removal of the zinc content is treated for lead, silver, copper by the usual smelting process.

Tin.

Detinning.—Another patent (862,866, Aug. 6, 1907) has been granted to Mr. C. E. Acker for the detinning of tin scrap. In the present case the scrap is partially submerged in an anhydrous liquid capable of directly dissolving or reacting on the tin and of evolving a vapor or gas which will react on the unsubmerged portions of the scrap. Liquid reagents which may be employed are solutions of chlorine or bromine in carbon tetrachloride or stannic chloride, or a solution of anhydrous hydrogen chloride in benzol or toluol. The solution is heated to furnish an atmosphere containing a considerable percentage of chlorine or bromine or hydrogen chloride. In some cases an additional supply of chlorine may be pumped into the receptacle during treatment.

Aluminium.

Solder.—C. Ellis (863,058, Aug. 13, 1907) patents a solder for aluminium which consists of "tin 30 parts, zinc 7 parts, aluminium ¾ part, manganese 1/10 part; or using chromium with manganese, tin 30 parts, zinc 8 parts, aluminium 1 part, manganese q. s., chromium 1/10 part."

Vanadium.

Leaching Process.—F. de Lucio (863,076, Aug. 13, 1907) proposes the following process of treating vanadium ores. Oxidized ores (or roasted sulphureted ores) are first boiled with a solution of hypochlorite of sodium, containing more than six atoms of sodium to one molecule of vanadic acid in the ore. This will oxidize all the vanadium to pentoxid, chlorine will be evolved, and the resulting vanadate of sodium is then dissolved as such and extracted with hot water. The solution of alkaline vanadate, when cold is treated with a like amount of hypochlorite of calcium. Vanadate of calcium is precipitated and hypochlorite of sodium regenerated, which latter can be used again for the treatment of new ores, increasing its content of alkaline hypochlorite to the required amount. The process therefore consumes only hypochlorite of calcium and steam.

Alloys

Substitute for Bronze.—W. Ruebel (804,139, Aug. 20, 1907) produces an alloy composed in accordance with the formula (CuFe)$_2$NiM. When 6 parts of this alloy are mixed and fused together with 54 parts of copper and 40 parts of zinc, the product is stated to cost about 1 mark (25 cents) per kw., and to equal in strength, hardness and resistance the best bronzes hitherto produced. It is, therefore, claimed to be suitable for replacing such bronzes. Rules are given concerning the procedure of repairing the alloy.

Bronze.—The same inventor (804,140, Aug. 20, 1907) patents an "atomic-weight alloy" of zinc, aluminium, silicon, copper, consisting of 65.4 parts of zinc, 27.1 aluminium, 28.4 silicon and 63.6 copper. If this alloy be added to alloys of copper and aluminium by taking, for instance, 8 kg. of copper, 769.2 aluminium and 238 grams of the above alloy, a bronze is said to be produced having 99.2 kg tensile strength, which is hard steel, but, nevertheless, readily adapted for forging and rolling. If in the above alloy silicon is omitted and pure nickel is substituted, so that the alloy contains 63.12 copper, 64.91 zinc, 20.91 aluminium and 58.3 nickel, the resulting bronze retains the strength of about 100 kg. per square mm. but the hardness has still further increased. The property of being readily forgible is not lost. These bronzes are said to be very resistive against chemical influences and to be particularly well adapted for shipbuilding purposes and for gun barrels. The limit of elasticity lies only 12 per cent below the rupture strength.

Miscellaneous.

Pebble Mills.—A patent granted to Max L. Abbe (858,129, May 25, 1907) relates to a lining for pebble mills. The cylindrical mill is provided with a number of natural lining stones, each embedded at the sides, ends and back in a coat of hardened cement.

Speed Recorder.

The importance of keeping a continuous record of the speed of blast-furnace blowing engines on a chart has been the incentive for Messrs. Edward Brown & Son, 311 Walnut Street, Philadelphia, to devise a new recording revolution indicator. How well the instrument is adapted for this purpose is shown by the adjoining illustrations.

Fig. 1 is a photograph of a chart taken from a Brown recording revolution indicator in use on a blowing-engine at an Eastern Pennsylvania furnace. It will be noted that the number of revolutions per minute fluctuates several revolutions at times. The hour or minute at which the engine has been slowed down or stopped is clearly shown.

Fig. 2 is a record made at the Youngstown Steel Co., Youngstown, Ohio, on a blast-furnace steam-blowing engine, and is a very fine chart, the number of revolutions having been kept within a quarter of a revolution except at stated intervals when the engine was stopped.

Fig. 3 is a reproduction of a chart taken from one of these instruments in use on a gas blowing-engine of a well-known type at the Park Gate Iron & Steel Co., Rotherham, England. It is evident that with the use of a gas blowing-engine the number of revolutions of the engine is subject to very sudden and great fluctuations. This is a feature that must be of considerable importance in the operation of blast furnaces with gas blowing-engines, for, according to the record illustrated, a fluctuation of as much as 10 revolutions per minute occurs at intervals of every few minutes except for a space of several hours, during which time the speed did not vary a revolution. It is difficult to give a reason for such a peculiar record unless the conditions in England are greatly different from those in the United States.

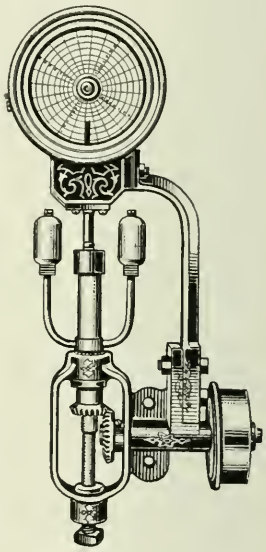


FIG. 5.—SPEED RECORDER.

Fig. 4 is a photographic reproduction of a chart used on the recording revolution indicator on a gas blowing engine at a well-known German works. It has been necessary to make some slight changes in the design of the instrument to suit the conditions in Germany, but this has not affected the successful use of the recorder.

The recording-revolution indicator itself, as illustrated in Fig. 5, is based on the law of centrifugal force, a body of mercury contained in a central chamber being thrown out into revolving arms proportional to the speed at which the instrument is driven. A float resting on the mercury is suitably connected to a pen arm which marks the record on the chart. These instruments have heretofore been furnished with a chart 6½ inches in diameter, but the inventors are now manufacturing the instrument with an 8-inch chart, affording wide graduations.

Although the recording-revolution indicator has heretofore been chiefly used on blast-furnace engines, there is nothing to prevent its successful operation on all types of engines, machines, dynamos and motors where a record of the instantaneous speed is desirable. It becomes daily more evident that the best method of control over a large plant is with the aid of recording instruments, which give a true picture of all conditions of working at any moment.

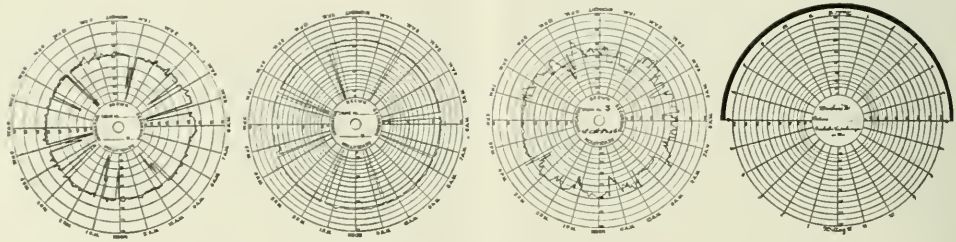


FIG. 1, 2, 3, 4.—SPEED RECORDER DIAGRAMS.

New York Meeting of the American Electrochemical Society.

The Autumn meeting of the American Electrochemical Society, which is to be held in New York City, will probably not take place in the first or second week, as had been intended, but in the second half of the fourth week. The dates will probably be Oct. 24 to 26, but the matter is to be definitely settled at a meeting of the New York Section called for Sept. 7.

As far as the program has already been prepared it appears that there will be a great many interesting papers presented.

All the meetings will probably be held at the Chemists' Club, and the convention will be opened by an evening session on Thursday, Oct. 24, when Mr. E. G. Acheson will present an experimental lecture on deflocculated graphite and Dr. George F. Kunz will speak on moissanite. Other sessions devoted to the reading and discussion of papers will be held on Friday morning and Saturday morning, and probably on Friday night.

On the electrometallurgy of iron and steel papers are expected from Dr. Eugene Haanel, Dr. R. S. Hutton, Mr. Gustave Gin, and a joint paper by Messrs. A. E. Green and F. S. MacGregor.

Dr. Allerton S. Cushman is expected to present an experimental lecture on the corrosion of iron as an electrochemical phenomenon, and papers on the same subject, or at least discussions of it, are expected from Dr. W. R. Whitney, Dr. W. H. Walker and Mr. C. J. Reed.

On the electrometallurgy of zinc a paper is expected from Mr. Gustav Gin, while Mr. C. E. Baker will discuss the use of chlorine in metallurgy.

Other papers are expected from Mr. F. A. J. FitzGerald on heat conductivity of graphitized carbon, from Mr. A. B. Marvin on electrochemical patents, from Drs. Patten and Robinson on the electrolytic reduction of nitric acid, from Mr. W. R. Mott on over-voltage, from Prof. Carhart on calculations of e. m. f. of concentration cells, from Dr. Weedon on the titanium arc, from Mr. E. E. Free on the electrolytic determination of minute quantities of copper. Messrs. Fireman, Becket, Guess, Hambuechen and Schlundt are also expected to present papers.

The program of the excursions and social functions will be made up on Sept. 7 at the meeting of the New York Section, and the full program will then be issued as soon as possible. It is hoped that a visit can be arranged to Mr. T. A. Edison's laboratories.

Autumn Meeting of the Iron and Steel Institute.

The Autumn meeting of the Iron and Steel Institute (London) will be held in Vienna, Austria, on Sept. 23 and 24, in the building of the Austrian Engineers' and Architects Society.

The list of papers to be presented is as follows:

On the Development of the Iron Industry of Austria since 1882. By W. Kestranek.

On the Styrian Erzberg Iron Ore Mines. By Prof. H. Bauerman.

On Steel and Meteoric Iron. By Prof. F. Berwerth.

On the Determination of the Quantity of Blast Furnace Gas for a Given Make of Pig Iron. By Prof. Josef von Ehrenwerth.

On the Application of the Laws of Physical Chemistry to the Metallurgy of Iron. By Baron H. von Juptner.

On Case Hardening of Mild Steel. By C. O. Bannister and J. W. Lambert.

On a New Blue-Black Paint as a Protective Covering for Iron. By F. J. R. Carulla.

On the Hardening of Steel. By L. Demozay.

On the Structure of Hardened Steel. By Percy Longmuir.

On Case Hardening. By G. Shaw Scott.

On the Ageing of Mild Steel: Further Notes. By C. E. Stromeyer.

On the Economical Distribution of Electric Power from Blast Furnaces. By B. H. Thwaite.

Notes.

Generators for Electrolytic Refineries. Bulletin No. 83 of the Crocker-Wheeler Company, of Ampere, N. J., gives an illustrated description of generators for electrolytic purposes, especially for copper refineries. The voltage of the usual types varies from 80 to 125 (the proper number of electrolytic cells being connected in series to suit the voltage), while the current is generally several thousand amperes. One of the illustrations shows two 1,050-kw., 10,000-amp., 100-r. p. m. generators, which are part of the 3,370-kw. equipment of the Crocker-Wheeler generators in the plant of the United States Metals Refining Co., of Chrome, N. J. The special requirements of electrolytic generators are that the voltage shall be stable through a wide range of adjustment, and that the generators shall run continuously at their rated loads, where continuously means 24 hours a day every day in the year. In cases of leakage increased current density, etc., the generators have even to carry considerable overloads. The pamphlet gives notes on general design construction of magnet frame, armature clearance, field coils, armature, commutator, brush rigging and mounting of armature.

Steam and Engineering Specialties.—The Schutte & Koerting Co., of Philadelphia, Pa., have just issued their export catalog for 1907 in the Spanish language, containing condensed illustrated descriptions of the many engineering specialties which they manufacture, such as steam jet exhausters and compressors, specialties for agitation of liquids and absorption of gases, lead exhausters and ventilators, valves, syphons, spray nozzles, sulphur furnace, etc.

The Colorado Iron Works Co. reports a very large business in smelting equipment during the past few months, the orders coming from all quarters. While the bulk of this business is from the United States and from Mexico, other foreign countries have been represented, and orders for either furnaces or complete smelting plants are now going through the shops for installation in France, Japan, Chile and New Zealand. The furnace included in the Chilean plant is designed for hot-blast smelting, and the New Zealand order embraces the complete equipment of a hot-blast copper matting plant with sampling plant.

The Denver Fire Clay Co., of Denver, Col., have sent us their illustrated catalog for 1907, which covers the following subjects: Chemists' and assayers' laboratory supplies, special chemical apparatus for analytical work, outfits for assayers and prospectors, school sets of chemical apparatus, collection of minerals, models and charts, fire-brick, tile and fire-clay material, chemicals and reagents.

Safe Blowing in Germany.—In the article by Mr. M. U. Schoop in our last issue (page 308) on a burner for cutting metals, he mentioned as a great advantage the possibility of opening by its means within a few minutes the largest "fire-proof safe." This is illustrated by the story of a robbery carried out by a single, unaided man in Dresden. This story is told in a recent Consular report as follows: "In a hotel a room was secured, which was situated immediately above the office of a money changer. At night a hole was pierced in the ceiling of the office. By the use of a drill and saw a circular piece of the flooring was easily raised. Beneath lay a thick layer of cement. A small orifice was made in this and an

...probably shoved down into the space below. The umbrella was attached firmly from above, and when opened received without loss all the fragments of cement which were dislodged as the hole was enlarged so as to allow of the easy passage of a person. By means of a rope ladder the descent was readily made into the office below. Curtains were drawn, and with heavy blankets a tent was constructed around the safe, so thick that no ray of light could pass through. Next the robber brought down two cylinders of compressed oxygen and an acetylene generator charged with calcium carbide and water. With these he was able to produce a blow-pipe flame of such intensity that steel fuses in it like lead in an ordinary gas jet. It required but a brief space of time to melt away so much of the door that all the contents of the safe were accessible. They were carried to the room above. At an early hour the robber left his lodgings and disappeared without trace."

The Production of Fluorspar in 1906.—The three principal classes of consumers of fluorspar are, in order of importance, smelters and metallurgists, makers of opalescent glass and enamelled wares, and chemical manufacturers, the various uses of material depending on its chemical composition, its fluxing properties, its phosphorescence when heated, and its optical and gem-like properties. Chemically it is calcium fluoride, and consists of calcium and fluorine in the proportions of 51.1 to 48.9. The mineral is crystalline, only slightly harder than calcite, and crushes easily. In color it ranges, according to purity, from a clear, slightly bluish, glass-like substance through various brilliant shades, although much of it is white and opaque. The mineral is usually very pure, the material marketed running from 98 to 99 per cent of calcium fluoride, while material carrying less than 95 per cent finds little sale. Associated with other minerals fluorspar has a broad distribution geographically and a wide range geologically. The deposits thus far exploited in the United States are, however, confined to five States—Arizona, Colorado, Illinois, Kentucky and Tennessee. The total production of marketed fluorspar in 1906 is reported by the United States Geological Survey in an advance chapter from *Mineral Resources of the United States, Calendar Year 1906*, at 40,796 short tons, valued at $244,025. These totals are less than those of 1905, which surpassed all previous records in quantity and average value per ton. The decrease in 1906 was perhaps due to over-production in 1905, resulting in surplus stocks which were sold in 1906, for at the close of 1906 the tendency of demand and prices was reported to be upward. Considerable fluorspar is imported at the present time, but the market is practically limited to the Atlantic Coast, as the cost of freight from English seaports to points west of New York tends to restrict the trade. English fluorspar has heretofore been cheap, at times selling at a price below the present cost of production, the shipments having been made from refuse dumps or abandoned lead mines, besides being brought to America as ballast, duty free. The local and the American demand will probably consume these English fluorspar mill-tailings within a few years, and thenceforth the material cannot be profitably exported to America, as the mines are closed. The chapter on fluorspar, with a few notes on cryolite production, was prepared by Ernest F. Burchard, of the survey, and includes a list of recent publications on the subject.

Obituary.

We record with regret the death of Sir William Perkin, which occurred on Sunday, July 14, at his residence at Sudbury, Middlesex, England. Sir William, who was best known as the founder of the coal-tar industry, was born in London in 1838, and received his technical education at the Royal College of Chemistry. While conducting researches on the possibility of artificially preparing quinine, he found the artificial dye-stuff mauve. This discovery and its adaptation led to the formation of the firm of Messrs. Perkin & Sons, and to the foundation of the aniline dye industry. Sir William Perkin's physical work chiefly consisted in researches on magnetic rotation for the results of which he was awarded the Davy and Longstaff medals. He was elected a Fellow of the Royal Society in 1880, and was awarded the Royal medal in 1879 and the Davy medal in 1889. He was president of the Chemical Society in 1883, and president of the Faraday Society during the present session. Sir William Perkin visited this country last year to attend the jubilee of the coal tar industry.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

Calcium Carbid (*Continued.*)

No. 588,012. Aug. 10, 1897. Isaiah L. Roberts, of Brooklyn, N. Y.

The apparatus is similar to that of the preceding patent, except that a reflecting dome of lime-brick or calcined limestone, enclosed in pulverized lime and brick work, is arranged over the arc to concentrate the heat upon the mixture below.

No. 598,592. Sept. 7, 1897. Sylvain Blum and Daniel J. Clark, of Galveston, Tex., and Sam Lazarus, of Sherman, Tex.

A charge for the production of calcium carbid, consisting of air-slaked lime, 22 bushels; pulverized carbon, 8 bushels; pulverized plumbago, containing iron, 4 bushels, and pulverized potash, $\frac{1}{2}$ bushel. The ingredients are mixed and smelted by an arc. The iron associated with the plumbago and the "potash or carbonate of potassium" act as fluxes, while the carbid contains "a trace of potash."

No. 589,067. Sept. 14, 1897. Robert F. S. Heath, of Camden, N. J.

A charge for the production of calcium carbid containing a small amount of sodium carbid, consisting of quick-lime, 9 parts, and carbon, 4 parts, plus ¼ ounce of sodium or potassium chlorid to each pound of mixed lime and carbon. Limestone, chalk or oyster shells may be substituted for quick-lime. The carbon may be coke, coal or charcoal.

No. 590,057. Sept. 14, 1897. William Henry Fahrney, of Chicago, Ill.

A plastic charge to be calcined into cement, or one for the production of calcium carbid, is continuously formed into a tube which is fed into one end of a combustion furnace. The flame from the furnace passes around and through the tube. The tube may be heated electrically instead of by combustion, by passing it through and in contact with a tubular carbon electrode, and thence springing an arc to a cylindrical carbon electrode at the end of the first electrode. As the tubular charge is smelted the product falls away from the annular space between the electrodes. The hot gases pass upward through the tubular charge and dry and pre-heat it.

No. 590,514. Sept. 21, 1897. Alfred H. Cowles, of Cleveland, Ohio.

Downwardly-inclined carbon electrodes are buried in a charge of lime and coke. An arc is sprung between them and a pool of molten calcium carbid forms within the charge. The electrodes are gradually separated, and the current thereupon flows from one electrode to the pool of carbid and thence to the other electrode. The voltage may be from 40 to 70. The charge protects the electrodes from oxidation and acts as a heat insulator. Additional charge material is fed in from time to time and settles downward between the electrodes. A portion of the molten carbid may be tapped out by pushing a bar obliquely upward through a side hole in the furnace wall and through the charge to the pool. This hole is closed with a plug after tapping.

NEW BOOKS.

The Elements of Chemical Engineering. By Dr. J. Grossman, with a preface by Sir William Ramsay. 152 pages, 50 illustrations. Bound in cloth. Price, $1.50. Philadelphia, Pa.: J. B. Lippincott Co.

A Laboratory Outline of General Chemistry.—By Alexander Smith. Third edition, revised in collaboration with W. J. Hale. 139 pages, illustrated. Bound in cloth. Price, 90 cents. New York: Century Co.

The Mineral Industry During 1906.—Its statistics, technology and trade. Vol. XV. Edited by Walter Renton Ingalls. 954 pages, illustrated. Bound in cloth. Price, $5. New York: Hill Publishing Co.

The Corrosion of Iron.—By Allerton S. Cushman. 35 pages, illustrated by diagrams. Bound in paper. Price, 15 cents. Washington, D. C.: Superintendent of Documents.

The United States Steel Corporation.—A study of the growth and influence of combinations in the iron and steel industry. By Abraham Beiglund. 180 pages. Bound in cloth. Price, $1.50 net. New York: The Macmillan Co.

The Copper Mines of the World.—A concise, geological and statistical study of the copper mines and deposits of all the world. By Walter Harvey Weed. 375 pages, 159 illustrations. Bound in cloth. Price, $4. New York: Hill Publishing Co.

Annuaire Universel des Mines et de la Metallurgie.—By Robert Pitaval. (Large edition, comprising the whole world.) Price, francs 15. Paris: Société Anonyme des Publications Scientifiques et Industrielles.

Petit Annaire Minier et Metallurgique.—By Robert Pitaval. (Small edition of the book mentioned before, relating to France and the French colonies only.) Price, francs 5. Paris: Société Anonyme des Publication Scientifiques.

United States Mining Laws and Regulations Thereunder—Approved May 21, 1907. 66 pages. Price 15 cents, paper binding. Washington, D. C.: U. S. office of the Superintendent of Documents.

Wilson's Mining Laws.—United States, Arizona, California, Nevada and Utah, with forms and corporation laws of Arizona. Second edition revised. 132 pages. Bound in cloth. Price, $1; paper binding, 50 cents. Los Angeles, Cal.: Baumgardt Pub. Co.

Concrete Steel Buildings.—By W. Noble Twelvetrees. 420 pages, illustrated. Bound in cloth. Price, $3.25 net. New York: The Macmillan Co.

The Mechanical Engineers' Reference Book.—A handbook of tables, formulas and methods for engineers, students and draftsmen. By Harrison Suplee. Third edition, revised and enlarged. 939 pages, illustrated. Bound in limp leather. Price, $5 net; with thumb index, $5.50 net. Philadelphia, Pa.: J. B. Lippincott Co.

Diagrams of Electrical Connections. By Cecil P. Poole. 113 pages; illustrated by diagrams. Price, $2.00. New York City: McGraw Publishing Co.

United States Lighthouse Board. Reports on use of acetylene gas by the Canadian Government as an illuminant for aids to navigation. 26 pages; illustrated. 5 cents. Superintendent of Documents.

Theta-Phi Diagram. Practically applied to steam, gas, oil and air engines. By Henry A. Golding. Second revised and enlarged edition. 126 pages; 48 illustrations. Price $1.25. New York City: D. Van Nostrand Co.

Massachusetts Statistics of Labor. Bureau of Manufactures, Massachusetts and other States. No. 2 (in Labor Bulletin No. 49), 1907. Bureau of Statistics of Labor, State House, Boston, Mass.

Technological Dictionary. In the English, Spanish, German and French languages. By A. C. Huehn. 660 pages. Price, $4.00. New York City: Spon & Chamberlain.

BOOK REVIEWS.

Metall-Analyse auf Electrochemischem Wege. By Dr. A. Hollard and L. Bertiaux. Authorized German translation by F. Warschauer. 125 pages. Price, bound, marks 6 (retail price in New York, $2.00). Berlin: M. Krayn.

It is always a praiseworthy undertaking for a chemical engineer to publish the results of his experience of years of practical work. It is especially praiseworthy if such a publication is not made in the special interests of the company with which he is connected. This praise is due to the authors of this work, which has been carefully translated into German by Dr. Warschauer, of Berlin.

The book consists of four parts, of which the first one is devoted to the principles of electro-analysis and classification of metals, while in the other parts the analysis of different metals and metallurgical products is specially discussed. The authors repeatedly call attention to the importance of the form of the electrodes for obtaining exact results, since the form of the electrodes is of influence on the distribution of the current density and on the diffusion phenomena. In general these two factors are not sufficiently taken into account, and especially chemists are inclined to think that the electric lines of force pass in straight paths from the points of the anode to the corresponding points of the cathode. This is only true in very special cases, for instance, when the electrolyte is contained in a cylinder and the top and the bottom cross-section of the cylinder form the two electrodes. In all other cases there is a stray field of lines of force as has been experimentally shown in the instructive paper of Mr. M. U. Schoop, published in one of the former volumes of this journal.

Of great interest is the chapter on the electrodes in which the constructions of Classen, Ribau and others are described, among them the platinum screen electrode of Hollard which has the great advantage that speedy diffusion is rendered possible and that the phenomena occurring at the electrode may be observed by the eye during a test.

The book does not carry any unnecessary matter in form of long tables, etc. Every analytical chemist and even every electrochemist should find something useful in the book, and will pardon the German publisher for the fact that some pictures (for instance, Figs. 6 and 8) remind one of wood cuts in Bibles of the 17th century.

* * *

The Copper Mines of the World. By Walter Harvey Weed. 375 pages; 159 illustrations. Price, $4.00. New York: Hill Publishing Co.

The tremendous advance in the mining and treatment of copper ores is concommittant with the rise of the electrical industry. Much attention to the metallurgical question has been given in the technical press, while the nature of mineral deposits that make copper mines has not been summarized in any book. To fill this known vacuum in technology is the purpose of this book.

The author, Mr. Weed, is well known for his work on the Geological Survey. Lately he has received deserved recognition from the captains of industry and has been retained by several large corporations as consulting geologist. This has given him an insight into commercial conditions. The benefit of this experience is seen in the comprehensive nature of this work for it not only treats of the science but always exhibits the commercial instinct. As a "mine" should connote the words "business success," we believe that this is a laudable mingling of the two elements of applied science.

The book is "confessedly a compilation." It further exhibits marks of haste in preparation. The geology of copper deposits has been often described by men who were frank adherents of the school of "lateral secretion by surface or meteoric waters." This has been rudely disturbed of late by evidences of "secondary enrichment" in Butte in the shape of large bodies of phe-

RECENTLY PUBLISHED

12mo, Cloth 498 Pages Price, $2.50 Net

Van Nostrand's
CHEMICAL ANNUAL
A Hand-book of Useful Data
for Analytical, Manufacturing and Investigating Chemists, and Chemical Students
Based on Biedermanns' "Chemiker Kalender"
EDITED BY
Prof. J. C. OLSEN, A. M., Ph. D.
Polytechnic Institute, Brooklyn
Formerly Fellow Johns-Hopkins University
Author of "Quantitative Chemical Analysis, by Gravimetric, Electrolytic, Volumetric and Gasometric Methods."
With the Co-operation of Eminent Chemists
FIRST YEAR OF ISSUE, 1907

The absence of a comprehensive reference book of numerical data of the Science, has induced the publishers to undertake the publication of this Annual, which it is their intention to issue, with new data added, annually.

8vo, Cloth 367 Pages Price, 3.00 Net

SOLUBILITIES
OF
Inorganic and Organic Substances
A Hand-book of the most
Reliable Quantitative Solubility Determinations
COMPILED BY
ATHERTON SEIDELL, Ph. D. (J.H.U.)
Bureau of Chemistry, U. S. Department of Agriculture

The principal features which have been emphasized in the preparation of this volume are as follows:

Completeness of Data
Uniformity of Expressing Results
Selection of Most Reliable Determinations
Arrangement of Material

8vo, Cloth, Illustrated, 298 pages Price, $3.00 Net

EXPERIMENTAL
Electrochemistry
Theoretically and Experimentally Treated
BY
N. MONROE HOPKINS, M. Sc., Ph. D.,
Assistant Professor of Chemistry in the George Washington University, Washington, D. C.
Profusely Illustrated with 130 New Drawings, Diagrams and Photographs, accompanied by a Bibliography.

D. VAN NOSTRAND COMPANY
Publishers and Booksellers
23 Murray and 27 Warren Sts., New York

nomenally rich ore at the 1,600, 2,000 and 2,400 feet level. It is inconceivable to any observer that this could have been effected by surface waters.

The more modern theory taken up by the school of younger geologists, to which the author belongs, is that of "expiring vulcanism." It attributes the formation of sulphide ores to the action of heated gases or solutions under pressure coming from the central part of the globe, the so-called "*barosphere*" and "secondary enrichment," in main, to the surging of these agents through an already formed deposit of low-grade ore catching up the copper from the heated portion and precipitating it in a cooler portion. Obviously this cooler portion might be at some depth.

The author usually seems to adopt this theory, though as it is in the transformation stage, his writings are colored at times by the old theories. For instance, on page 46, lines 16 to 20, he expresses the older theory without, however, the adjective "surface" or "meteoric," while on page 30, lines 3-5, he states that the occurrence of deposits of [rich] enargite at depths of 2,000 feet is opposed to the fact that enargite is secondary ore. On pages 54 and 55, however, he clearly states the genesis of ore deposits, allowing secondary enrichment by later igneous hydrothermal activity a much more prominent part.

Again on page 70 in the classification of ore deposits he places the Sudbury copper-nickel deposits as "segregations from basic igneous rocks." The term "segregation" is a wide one, and may mean either separation the way matte and slag are separated or a segregation by hydrothermal activity. We could wish the author had been less like the oracle at Delphi in this. Mr. D. H. Browne was of the opinion that the first hypothesis was the correct one. On the other hand, it would seem that the microscopic work of Kemp and his pupils has given importance to the latter ideas, though Prof. Kemp is not at all positive in his declarations.

However, it would be idle to criticize too much a book so excellent whose faults are due chiefly to the fact that economic geology is a most stubborn and unsatisfactory science. As Mr. Weed says, "facts are facts," to be used, to be studied, and to be studied and used again. This book presents chiefly facts and allows the reader to dig out his theories.

* * *

CONTRIBUTIONS TO ECONOMIC GEOLOGY, 1906.—Part I.: Metals and nonmetals, except fuels. By C. F. Emmons and E. C. Eckels. 510 pages. Washington: Department of the Interior, U. S. Geological Survey, Bulletin No. 315. Series A, Economic Geology, 95.

This is the fifth of a series of bulletins of the U. S. Geological Survey, entitled "Contributions to Economic Geology." For the first time this bulletin has been divided into two parts, as a result of the division of the former section of iron ores and non-metallic minerals, Mr. M. R. Campbell being placed in charge of a new section devoted to the investigation of fuels, including coal, oil, gas and asphalts, and Mr. E. C. Eckel remaining in charge of investigations of iron ores, structural materials and miscellaneous non-metals. This change in the Survey organization has been used as a basis for a separation of the economic bulletin based on subjects. The present bulletin covers the work of the Survey in 1906 in metals, structural materials and other non-metals, except fuels. A separate bulletin will be issued later, covering Survey work on coal, lignite and peat.

Besides summaries of the work of the Survey in 1906 with respect to metalliferous ores, iron ores and structural materials, reports are given on gold and silver in Colorado, Montana, Washington and Wyoming; copper in Wyoming; nickel in Colorado, Maine, Oregon; iron and manganese ores in Alabama, Pennsylvania, Wyoming; aluminium and bauxite in New Mexico; Portland cement in Iowa and Wyoming; limestone in Alabama; gypsum in New Mexico; clays in Alabama,

Colorado, New Mexico, Georgia, Missouri, Pennsylvania; building stone and road metal in New England; glass sand in Indiana, Kentucky, Ohio and elsewhere; quartz and feldspar in Maine, New York; mica in North Carolina and Wyoming; graphite in Wyoming; mineral paint ores in Pennsylvania (and an article by E. F. Burchard, on Southern red hematite as an ingredient of metallic paint); abrasive materials in California; phosphorus ore in Western United States, Arkansas, Pennsylvania; sulphur in Utah.

* * * * *

GYPSUM AND GYPSUM PRODUCTS IN 1906. By Ernest F. Burchard. Washington: Department of the Interior, United States Geological Survey.

This pamphlet of 14 pages is an advance chapter from *Mineral Resources of the United States* for 1906. The first parts discuss the character of gypsum with analyses, the range and distribution of gypsum, uses of gypsum and the chemistry and practice of gypsum burning and the making of plaster of paris. After a review of the condition of the trade, statistical tables are given on the production in the United States and other countries. The gypsum mined in the United States in 1906 amounted to 1,540,585 short tons, valued at $1,147,129. This production represents an increase in quantity of more than 47 per cent, and in value of nearly 40 per cent, as compared with that of 1905.

* * * * *

LABORATORIUMSBUCH FÜR DEN EISENHÜTTEN CHEMIKER. By Max Orthey. 49 pages. Price, mark. 1.80 (retail price in New York, 60 cents). Halle a. S.: Wilhelm Knapp.

This little book is Part I. of a series of fourteen laboratoriumsbücher which are to deal in a brief and practical manner with the different branches of technical analytical chemistry. The book contains schemes for the "sufficiently exact" determination of the constituents of iron ores, iron and steel, slags, limestone, refractory materials, fuels and gases.

A few samples of the methods are as follows: Silicon in pig iron is determined by dissolving in hydrochloric acid, evaporating to dryness, redissolving, filtering and weighing as SiO_2, regardless of the titanic acid often present. The nitric and sulphuric acid method used in this country is fully as rapid and is free from this serious source of error. Carbon is determined by solution in copper ammonium chloride with combustion of the carbon residue in chromic and sulphuric acids.

In determining phosphorus 1 gram of iron is dissolved in nitric acid, transferred to a porcelain dish and evaporated to dryness on a sand bath. Phosphorus is peroxidized by roasting one-half hour over a Bunsen flame. The residue is then treated as an iron ore.

While there is much that is interesting in this work, it is not probable that the methods proposed will find favor with American iron chemists.

* * * * *

TRANSACTIONS OF THE FARADAY SOCIETY. Vol. III., Part 1., 102 pages; illustrated. Price, 10s. 6d. London: The Faraday Society.

This issue is introduced by a highly theoretical paper of F. E. Fournier-d'Albe on the application of the electron theory to electrolysis, followed by an interesting symposium of papers on osmotic pressure with an extended discussion of the subject. The Earl of Berkeley discusses the direct measurement of osmotic pressure, Mr. W. C. Dampier Whetham indirect methods of measuring osmotic pressure, Dr. T. Martin Lowry the osmotic pressure from the standpoint of the kinetic theory, Dr. L. Kahlenberg (University of Wisconsin) the bearing of actual osmotic experiments upon the conception of the nature of solutions. The chief points brought out in this discussion have already been covered in our columns.

The second half of the book consists of more or less

BOOKS PURCHASED BY THE FEDERAL GOVERNMENT

For the use of Inspectors under the new Food and Drugs Act, 1907

Autenrieth. "The Detection of Poisons and Strong Drugs"	$1.50
Heusler. "Chemistry of the Terpenes"	4.00
Leffmann and Beam. "Select Methods in Food Analysis," 2d Edition ..	2.50
Richter. "Organic Chemistry," 3d Edition, by E. F. Smith. Two Volumes	6.00
Sayre. "Organic Materia Medica and Therapeutics," 3d Edition	5.00
Thresh and Porter. "Preservatives in Food and Food Examination" ..	4.50
Allen. "Commercial Organic Analysis," 9 Volumes	34.50
United States Pharmacopœia, 8th Revision	2.50
Sutton. "Volumetric Analysis," 9th Ed'n	5.00
Greenish. "Microscopical Examination of Foods and Drugs"	3.50

Circulars of These Books Upon Application

P. BLAKISTON'S SON & CO.
PUBLISHERS
1012 Walnut Street Philadelphia

Handbook of Mathematics

FOR ENGINEERS AND ENGINEERING STUDENTS

By J. CLAUDEL

Translated and Edited from the Seventh French Edition by OTIS ALLEN KENYON

A complete book on Mathematics
It covers very thoroughly
Every branch from Arithmetic to Calculus

TABLE OF CONTENTS

PART I.—ARITHMETIC. I.—Fundamental Operations on Whole Numbers. II.—Properties of Whole Divisors. III.—Fractions and Decimal Numbers. IV. Powers and Roots. V.—Ratios, Proportions, Progressions. VI.—Diverse Rules. VII.—Logarithms. PART II.—ALGEBRA. I.—Of the Four Fundamental Algebraic Operations. II.—Equations of the First Degree. III.—Powers and Roots of the Algebraic Quantities. IV.—Equations of the Second Degree. PART III.—GEOMETRY. Plane Geometry. Solid Geometry. Problems in Geometry. PART IV.—TRIGONOMETRY.—Plane. Spherical Trigonometry. PART V.—ANALYTICAL GEOMETRY. PART VI.—CALCULUS. I.—Differential Calculus. II.—Integral Calculus. III.—Applications of Integral Calculus.

Cloth, 708 Pages. 422 Illustrations. Price, $3.50 Net.
Sent anywhere postpaid for the price
Send Us Your Inquiries Write For Our Catalogs

McGraw Publishing Company
PUBLISHERS, IMPORTERS AND BOOKSELLERS
239 West 39th Street, New York

theoretical papers by H. Nutton and H. D. Law on the potential of hydrogen liberated from metallic surfaces, by F. M. G. Johnson and N. T. M. Wilsmore, on electrode potentials in liquid ammonia, by J. G. A. Rhodin on the impedance of solutes in solvents as manifested by osmotic "pressure," and by T. S. Price on the electrolytic deposition of zinc, using rotating electrodes.

Sandwiched in between these sets of scientific papers—many of which are of considerable intrinsic value—we find a commercial paper by J. B. C. Kershaw on the present position and future prospects of the electrolytic alkali and bleach industry. This industry is now so important that a thoroughly up-to-date and reliable review of it would be very valuable. But it seems impossible to prepare such a review at present. Mr. Kershaw's statistical figures are to the larger part confessedly not authoritative; in his opening remarks he regrets "the excessive modesty of electrochemical firms about their achievements, or the objection there is on the part of manufacturers to allow the world to know what is being done and what progress is being made."

Mr. Kershaw's paper begins with historical notes, mostly relating to early history; then follow statistical tables of the different companies in different countries working electrolytic alkali processes, with more or less incomplete data as to equipment. How far the data are exact or up to date may perhaps be judged from the notes on three of the six American companies noticed. No. 26, the Pennsylvania Salt Co., is stated to work the Bell Bros. mercury process at Wyandotte; this is ancient history; this process has indeed been used there on an experimental scale, but has long since been abandoned. Under No. 27, the works of the Roberts Chemical Co., at Niagara Falls, are reported "to have been burnt down recently." This has happened in August or September, 1905, but thy have been rebuilt soon afterwards and have since been in working order. The reverse is the case with No. 28, the Acker Process Co., at Niagara Falls; these works burnt down this Spring and have not been rebuilt, so that there exists no longer any industrial process electrolyzing fused salt for chlorine and caustic production. Mr Kershaw cannot be blamed, however, for stating this process as one in operation, since the fire occurred after his paper had been read. It is also stated that "a new works, using the Townsend diaphragm cell, is about to be started in Niagara Falls"; this plant has been in commercial operation for more than a year and a half. There are other smaller inaccuracies; for instance, Mr. Kershaw wants to restrict his notes to "electrolytic alkali works," but gives in his tables, nevertheless, the works of the Dow Chemical Co., in Midland, Mich., which do not make caustic. It is to be hoped that the data on European plants—incomplete as they confessedly are—are more correct. But it is suspicious that no mention is made of the inroads which the Glocken process is now making in German plants.

The paper is concluded by interesting remarks on the probable future of the electrolytic industry. In these the author seems to be more fortunate than in his statistics. His conclusions given here are practically identical with those given by himself in an article in Electrochemical and Metallurgical Industry Vol. IV., p. 173.

* * * * *

Open-Hearth Steel Castings. By W. M. Carr. 118 pages; 19 illustrations. Price, $1.50. Cleveland: The Penton Publishing Co.

This little book is compiled from a series of articles by the author, published in *The Iron Trade Review* and *The Foundry*. It will be found a useful and quite complete summary of the chief points which require attention in the manufacture of open-hearth steel castings, both by the basic and acid process. The book is practical and fully up to date; thus, the eleventh chapter gives an exposition of the repair of steel castings by the thermit process.

PALMER—*Practical Test-Book of Chemistry.* Including Specific Tests and Tests for Purity. 12mo, x + 190 pages. Cloth, $1.00.

Extract from Preface.—"In collecting these Tests and arranging them alphabetically, an effort is made to supply physicians engaged in practice, and pharmacists, with a ready means and safe guide for testing any substance presented for examination. And as only practical information is aimed at, the methods employed are very simple and form a series of unpretentious experiments."

GOOCH-BROWNING—*Outlines of Qualitative Chemical Analysis.* Small 8vo, vi + 145 pages. Cloth, $1.25 net.

MORGAN—*The Elements of Physical Chemistry.* Third Edition, Revised and Enlarged. 12mo, xii + 510 pages, 21 figures. Cloth, $3.00.

MORGAN—*Physical Chemistry for Electrical Engineers.* 12mo, viii + 230 pages. $1.50 net.

JOHN WILEY & SONS
43 & 45 E. 19th St. New York City

Eleventh Edition

Metallurgy of Cast Iron

A complete exposition of the processes involved in its treatment, chemically and physically, from the blast furnace through the foundry to the testing machine, being a practical compilation of original research.

By THOMAS D. WEST

Contents

PART I.—Manufacture and Use of Coke—Properties in Ores—Operations of Blast Furnaces—The Different Brands of Pig-Iron and How to Purchase and Use Them Intelligently (27 chapters). II.—Elements in Cast-Iron and Their Physical Effect—Utility of Chemical Analyses and How to Use Them in Making the Different Mixtures of Irons Used in Making Gray and Chilled Castings (21 chapters). III.—Properties of and Methods for Testing Molten Iron—Phenomena in the Actions of Cooling Metal, etc.—Results of Tests in All Kinds of Irons—Best Methods for Testing (23 chapters). APPENDIX. Selected Tables for Use in Furnace and Foundry Work.

Cloth 638 Pages 153 Illustrations Price, $3.00 net

Sent Anywhere, postpaid, for the Price by the

McGRAW PUBLISHING COMPANY

239 West 39th Street :: New York

Electrochemical and Metallurgical Industry

VOL. V. NEW YORK, OCTOBER, 1907. NO. 10.

Electrochemical and Metallurgical Industry

With which is Incorporated Iron and Steel Magazine

Published on the first of each month by the
ELECTROCHEMICAL PUBLISHING COMPANY,
[*Incorporated.*]
239 WEST 39TH STREET, NEW YORK.

J. W. RICHARDS, PH. D.....*President*
E. F. ROEBER, PH. D.....*Editor and Secretary*
C. E. WHITTLESEY.....*Treasurer*

Subscription Price: $2 per year, postpaid to any part of the world. Single copies 25 cents.

Copyrighted, 1907, by the Electrochemical Publishing Co.

Entered as Second-Class Matter, June 1903, at the Post-Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, OCTOBER, 1907.

CONTENTS.

EDITORIAL 387
New York Meeting of the American Electrochemical Society... 387
Metallography in its Practical Applications..... 387
The Old and the New Peat Problem..... 388
Technical Education 389
Program of New York Meeting of American Electrochemical Society 390
The Iron and Steel Market..... 390
The Danger of Overspecialization. By Leo Backeland 391
CORRESPONDENCE:
Utilization of Peat for the Generation of Power and the Production of Artificial Manure. By A. Frank 392
Vienna Meeting of the Iron and Steel Institute 393
W. Kestranek on The Austrian Iron Industry..... 393
J. von Ehrenwerth on the Determination of Blast Furnace Gas. 394
B. H. Thwaite on Economic Distribution of Electric Power from Blast Furnaces 394
C. E. Stromeyer on Ageing of Mild Steel 395
F. J. R. Carulla on a New Iron Paint and a New Application of Calcium Chloride from the Pickling Process 395
G. Shaw Scott and C. O. Bannister and W. J. Lambert on Case Hardening 396
Percy Longmuir on Hardened Steels and Metallography 397
L. Demozay on Hardening of Steel..... 397
Fred Berwerth on Steel and Meteoric Iron 398
H. Bauerman on The Erzberg of Eisenerz 398
Producer Gas-Fired Muffle Furnace. By Oskar Nagel 398
Metallurgical Calculations (Electrometallurgy of Copper). By J. W. Richards 398
The Utilization of Peat for Power Purposes with the Recuperation of By-products. By A. Frank and J. Carl 405
Production of Phosphorus in the Electric Furnace 407
NOTES ON ELECTROCHEMISTRY AND METALLURGY IN GREAT BRITAIN 409
ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS 411
SYNOPSIS OF PERIODICAL LITERATURE 420
RECENT METALLURGICAL PATENTS 424
Industrial Liquid Air..... 426
Electric Muffle Furnace 428
Electric Annealing and Hardening Furnace 428
Alloys for Steel Manufacture..... 429
NOTES 429
DIGEST OF UNITED STATES PATENTS (Calcium Carbide) 430
NEW BOOKS 431
BOOK REVIEWS:
W. R. Ingalls' Mineral Industry, 1906 431
D'Arcy Weatherbe on Dredging Gold in California 431
L. S. Austin's The Fire Assay of Gold, Silver and Lead Ores and Metallurgical Products 432
W. M. Carr's Open-Hearth Steel Castings 432
J. Grossman's Elements of Chemical Engineering 433
Merck's 1907 Index..... 434

New York Meeting of The American Electrochemical Society

The program of the coming New York meeting of the American Electrochemical Society, which is found in full elsewhere in this issue, contains various attractive features to which we wish to call attention. The meeting will be held on Thursday, Friday and Saturday of the third week of October, and will be opened on the evening of Thursday, Oct. 17, by a session at the Chemists' Club. Two lectures by Mr. Acheson and Dr. Kunz on subjects of great general interest have been wisely selected for this first evening session, and it is hoped that everyone who intends to attend the meeting will not miss this session on the first evening. The papers selected for the morning sessions of Friday deal with a variety of timely and important problems of electrometallurgy. A special feature of the Saturday morning meeting will be Dr. Cushman's lecture with demonstrations on the electrochemical theory of the corrosion of iron. In the afternoons a visit to the laboratories of Mr. Thomas Alva Edison, who will personally receive the party, and an excursion to the splendid electrolytic copper refining works at Chrome will certainly prove very alluring. These excursions and the banquet on Friday night, to which ladies are most cordially invited, will, it is hoped, offer the fullest opportunities for social intercourse. The Chemists' Club and Columbia University will be the hosts of the Society at the different sessions, and the meeting will be closed by one of the charming smokers at the Chemists' Club for which its house committee is renowned.

◆◆◆

Metallography in Its Practical Applications

Mr. P. Longmuir's paper, read at the Vienna meeting of the Iron and Steel Institute, and given in extract elsewhere in this issue, contains a warning which should be heeded. Neither the Iron and Steel Institute nor the author of that paper can be said to be antagonistic to metallography. Such statements as the following are therefore remarkable: "As a matter of fact no metallographical investigation yet published has been of the least service as a guide to the thermal treatment of high-speed steels." We know that this view is shared by influential, practical steel men in this country. Yet it would be dead wrong to condemn metallography as a whole. Mr. Longmuir's suggestions as to closer intercourse between metallography and practical work, deserve, however, the fullest attention.

◆◆◆

The Old and the New Peat Problem

Such enormous amounts of energy, time and money have been spent in the past on endeavors to solve the peat problem, that the practical results which have been attained seem

almost meagre part compared with the efforts made. The last Geological Survey report for 1906, by Mr. Marius R. Campbell is rather discouraging. "During the year 1906 scarcely any advance was made in the utilization of peat in the United States. About the usual number of companies were organized and glowing prospectuses were issued, but little or nothing was done toward the development of the peat industry in general. Many of the plants that were in operation experimentally in 1905 closed down during the year, so that at the end of 1906 it is probable that there were fewer plants in operation than at the close of 1905." Nevertheless, it would be folly to think that the peat problem was dead. It would be a very lively corpse, indeed, if we consider that those chiefly interested in the development of American peat and swamp lands are just about to organize an American Peat Association. The circular letter which has been sent out to this effect is signed by competent men. Dr. Joseph Hyde Pratt acts as temporary chairman, and the first meeting is to be held at the Jamestown Exposition at the end of October.

* * *

It is not difficult to see why the interest in the peat problem cannot be subdued. The chief reasons are on one side, the enormous extention of peat deposit areas, at present practically worthless, and on the other side the undeniable fact that peat, according to its chemical composition, contains so considerable material values and energy values that their recovery would be highly desirable. But the process of recovery should be cheap, its cost should certainly be considerably less than the amount of the values to be recovered. This is the great difficulty. We might compare the peat problem with a very low-grade ore proposition. As long as high-grade ores are available, low-grade ore propositions are not very attractive. But in recent years we have seen great changes in the attractiveness of such propositions in the case of several metals, both as the result of the scarcity of high-grade ore and of the advances made in the metallurgical art. The peat problem may be considered from the same point of view. There have been considerable changes in recent years in the object aimed at as well as in the means for handling the peat.

* * *

Let us first consider the object. In the old peat problem the object was to convert the peat into fuel suitable for both domestic and steaming purposes, this fuel to be shipped to consumers to compete with coal. In the new peat problem the object is to erect plants in the peat districts themselves for recovery of the values. Two essentially different means are available. One is dry distillation for the production of coke, with recovery of the by-products. The other is using the peat in gas producers for the production of power, also with recovery of by-products. With respect to the by-products, the nitrogen content of the peat is significant, since it is possible to recover it in form of ammonium sulphate; in view of the rapidly increasing importance of the artificial fertilizer industry the fixation of the nitrogen in peat is certainly as attractive a problem as the fixation of atmospheric nitrogen. Concerning the coke produced from dry distillation of peat it is to be pointed out that its quality naturally depends on the composition of the raw peat, especially its ash contents, but that its freedom from sulphur should go a long way to make peat coke desirable for metallurgical purposes. Finally, as to the desirability of producing cheap power from peat there can hardly be any disagreement of opinion. If power can be produced cheap enough there will be uses for it even in peat districts which have not yet any industry.

* * *

Secondly, concerning the means of treating peat. All the essential troubles with peat are due to its content of water and to its porosity. Much has been done in the construction of suitable machinery for kneading and treating the peat, so as to mold it and remove a considerable portion of the water. For the dry distillation of peat, the enormous advances which have been made in by-product coke ovens for the dry distillation of coal are of direct importance. Finally, as to the development of power from peat, the whole idea of doing this has become possible only through the development of the modern gas producer and large gas engine. It is evident there are vast possibilities, but it should not be amiss to finally sum up what has been actually achieved.

* * *

According to Mr. Campbell's Geological Survey report, three companies have worked on an experimental scale in 1906 in this country. The Winter Park Electric & Fuel Co., in Orlando, Fla., which uses the Leavitt machine; the Wolverine Peat Fuel Co., near Vicksburg, Mich., which uses the Dolberg machine, and the Lamertine Heat, Light & Power Co., near Vicksburg, Mich., which uses a machine of special type owned by the company. The method of handling the peat is essentially the same in the three plants, namely, digging from bog either by hand or machine; transporting in car or conveying apparatus to mill; disintegrating in mill; molding into bricks, and finally drying by natural exposure until the water is reduced to about 15 or 20 per cent. The Winter Park Electric & Fuel Co. has departed from this practice slightly, as it now dispenses with the molding into bricks, simply dumping the disintegrated peat on the ground and letting it dry in irregular masses, which later are broken with hammers into lumps. This is reported to give excellent satisfaction; it is cheaper, though it requires more space for storage. A very complete plant, that of the International Fuel & Power Co., is nearly ready for operation at a bog located not far from Ogdensburg, N. Y. It is built on a large dredge, and the progress of the peat through the machine from the time it leaves the bog until it is delivered in the form of briquets is entirely automatic. The bog is located on the east side of Black Lake, in a position that makes dredging operation easy. The peat is raised from the bog in bucket conveyors, dropped into the hopper of a disintegrating machine, passed through steam-jacketed pipes to drive off moisture, and then, while hot, is briquetted under immense pressure. The product, according to the claims of the company, contains less than 5 per cent of moisture. Mr. Campbell comments on the prospects of this work as follows: "This plant is very complete and well built, and there seems to be little doubt that briquets can be successfully produced; but whether they can be made cheaply enough to compete with Pennsylvania soft coal at $3.25 per ton seems to be a question. Doubt-

less, if this operation is successful, it will lead to the utilization of many other peat bogs in Northern New York."

* * *

As to the dry distillation of peat and the use of peat in gas producers, most of the work has been done abroad. A review of a series of papers by two enthusiastic workers in this field, Prof. Frank and Dr. Caro, will be found elsewhere in this issue and contains much interesting information. It appears that dry distillation of peat is commercially successful in one or two German plants. In this country it is hardly to be expected that much will be done in this line until the dry distillation of coal in by-product coke ovens has conquered the whole field that will be surely contributary to it. As to the use of peat in gas producers, Mr. Campbell states that Florida machine peat yields fully as good results as Texas and North Dakota lignites. In comparative tests it was found that 1 pound of Florida peat yields 0.330 electric horsepower, against 0.335, 0.309 and 0.308 for three kinds of North Dakota lignite, and 0.388 and 0.299 for two kinds of Texas lignite. Mr. Campbell says: "Probably the two most important questions yet unsolved are to determine the maximum amount of moisture that can be used in a producer and whether it is necessary to disintegrate the peat and mold it into bricks." It is with respect to these points that the papers of Frank and Caro, reviewed in this issue, give very interesting data on the basis of the results obtained on an experimental scale in a Mond gas plant in England. If the same results can be obtained in general on a large scale the process will be, indeed, very promising. The ammonium sulphate could then hardly be called a by-product, while the power—the excess of power over that needed in the plant itself—would be all "velvet" to the process. The outcome of the operation of the process at the Mont Cenis mine will decide whatever may be doubtful at present.

Technical Education

We have long held to the theorem that the advance in applied science has been the great factor in the material progress of the past fifty years, as the science itself has made inroads on, and upset theological and philosophical thought. The great advance of Germany in commerce and industry has been a steady and persistent application of the principles of physical and chemical science to increasing the efficiency of industrial processes. This is seen in the whole world of the gamut of the little hand-sewing machine used by the Hindoo maid to the great steel rolling mills of Pittsburg. It is the intelligent application of the methods and principles of science that have enabled the complicated organism of modern society to have its rapid growth in multifarious directions. Germany has also been the leader in systematizing the methods for giving the youth the requisite training in the principles of science and the methods of engineering. We Americans cannot but give due tribute to our Teutonic cousins for this pioneer work. The Technische Hochschulen and the Reichsanstalt are concrete evidences of it.

* * *

In America we have followed in the same trail and with our energy and resource have built up a system of technical education that produces excellent results, though still better things can be expected in the future. To the young engineering students, now entering upon the new year, certain advice can be given. The first is to study general principles, to learn to look at things in a broad way, not merely at details, but to store up a knowledge to comprehend the architectonics of their profession. This is the trend of all modern educational methods nowadays. It is less a matter of acquiring knowledge than rather of acquiring the ability to know how to acquire knowledge. One of the most practical reasons for this is that in after life early specialization is useless because some fortuitous circumstance will make the metallurgist an electrical engineer, or the mathematical engineer a salesman. In business as in all life "Thomme propose, le Dieu dispose." We fully agree with the general sentiment in Dr. Backeland's recent lecture on the dangers of over-specialization, extracts from which will be found on another page of this issue. The allround man, trained in the fundamentals of science, and who knows engineering principles, will never fail to learn the details of his specialty as he works if he has been trained to use his mind independently and broadly. As to the intrinsic value of theories in science, J. J. Thomson's remark, that scientific theories represent a policy, rather than a creed, is highly suggestive. The earlier we learn to understand the wisdom of this remark, the greater will be for us the usefulness of theories.

* * *

Another good bit of advice is to learn, know and practice hygiene. Hard knocks will come to every mother's son in this present evil world. But he who knows hygiene of the body, mind and feelings, can rise superior to fate to take his lot like a brave soldier does death with the exclamation "kismet." And after all this, moral and mental welfare are so much more easily built if the solid foundation of physical health is laid. The example of Gladstone and Roosevelt shows that health is open to every one who will exercise his will. Many a great battle has been lost, many a business wrecked, many a noble poem unwritten for disregard of this cardinal principle. The poorest of us are capable of great things at times, provided our nerves are calm and under control. The lesson of self control is a hard one, to be learned only by fighting. But bodily health comes thereby, and with it all the rest. It is useless to give too much good advice—the young usually disregard it, but we furthermore counsel young engineering students to study broadly literature, to learn not only correct thinking, but also concise expression of their thoughts. For the time will come when the powers of writing and speaking well and to the point will turn the balance betwixt mediocrity and eminence. In addition we would say to them, study sociological and industrial conditions, the first to learn to treat workmen from a standpoint of enlightened self-interest, the second to know how to use the forces of nature to produce financial returns, which let us affirm is the criterion of all engineering success. A knowledge of political economy will do this, provided the student is practical and can judge of facts as he sees them, and not in the light of preconceived notions. In conclusion, it may be said, that real wealth is measured by contentment which comes from a task well done. Activity and honesty are the only causes of true human happiness.

American Electrochemical Society.

The twelfth general meeting of the American Electrochemical Society will be held in New York City, Oct. 17, 18, 19 (Thursday, Friday and Saturday of the third week of October).

The meeting will be opened by an evening session on Thursday, Oct. 17. This session, as well as the morning session on Friday, Oct. 18, will be held at the Chemists' Club, 108 West Fifty-fifth Street. The morning session of Oct. 19 will be held in Havemeyer Hall, Columbia University.

Headquarters for registering and information are at the Chemists' Club. Hotel headquarters are at the Hotel Cumberland, Fifty-fourth Street and Broadway.

On Friday afternoon an excursion will be made to the laboratories of Mr. Thomas A. Edison. Mr. Edison will receive the visitors personally. A special car will be provided on the Delaware, Lackawanna & Western Railroad, the train leaving West Twenty-third Street at 2.15. On the evening of Friday a subscription dinner will be held in Liederkranz Hall. Ladies are specially invited.

On Saturday afternoon an excursion will be made to the new Pennsylvania Railroad power plant at Long Island City, the New York Electrical Testing Laboratories and the large electrolytic copper refinery of the United States Metal Refining Co., at Chrome, N. J.

On the evening of Saturday a smoker will be tendered to the American Electrochemical Society by the Chemists' Club.

During the meetings there will be an exhibition of some novelties of electrochemical products and apparatus at the Chemists' Club.

The program of papers is as follows:

THURSDAY EVENING, at 8 P. M., reception and session at Chemists' Club; 8.40 P. M., illustrated lecture on Diamond and Moissanite, Natural, Artificial and Meteoric, by Dr. George F. Kunz; 9.30 P. M., lecture on Deflocculated Graphite, by Mr. E. G. Acheson, of Niagara Falls, with demonstrations and experiments.

FRIDAY MORNING SESSION, at Chemists' Club, at 9 A. M.—On the Electrothermic Reduction of Iron Ores. Messrs. Albert E. Greene and Frank S. MacGregor.

Discussion of the Electric Furnace Experiments for the Production of Pig iron at the Soo. Dr. J. W. Richards.

Silicon Monoxide and "Monox," a new product of a novel electric furnace. Dr. H. N. Potter.

Discussion of Moissan's Experiments on the Boiling Points of the Metals. Dr. O. P. Watts.

The Electrometallurgy of Zinc. M. Gustave Gin.

A New Application of Chlorine in Metallurgy. Mr. C. E. Baker.

The Heat Conductivity of Carbon. Mr. F. A. J. FitzGerald.

Granular Carbon Resistors. Prof. S. A. Tucker.

SATURDAY MORNING SESSION, at Columbia University, at 9 A. M.—Physico-Chemical Notes on the Alummates of Soda. Mr. P. B. Sadtler.

Action of Ammonium Persulphates on Metals. Mr. J. W. Turrentine.

Note on the Use of the Capillary Electrometer for Alternating Voltages. Mr. H. G. Floyd.

Electroscopic Determination of Radium in Some Tufa at Hot Springs, Ark. Dr. Herman Schlundt.

Electrolytic Separation of Silver and Copper. Mr. H. W. Gillett.

Electrolytic Determination of Minute Quantities of Copper. Mr. E. E. Free.

Electrolytic Reduction of Nitric Acid. Drs. H. E. Patten and Robinson.

Electrochemical Methods for the Qualitative and Quantitative Determination of Free Silicon in the Presence of Silica, Silicates, Oxides, Free Carbon and Carborundum. Mr. W. R. Mott.

On the Nature of Electrolytic Conductors. Dr. L. Kahlenberg.

The Treatment of Storage Battery Elements Before Putting Them Out of Commission. Prof. O. W. Brown.

Further Study of Concentration Cells. Dr. Hy. S. Carhart.

The Electrolytic Theory of the Corrosion of Iron. Dr. A. S. Cushman (lecture with demonstrations).

Advance copies of the papers of Baker, Carhart, Free, Gin, Mott, Schlundt and Watts are being printed, and will be sent to any member who applies for them by the Secretary, Prof. J. W. Richards, Lehigh University, South Bethlehem, Pa.

Prof. S. A. Tucker, Columbia University, is chairman of the New York committee. Mr. Abôs von Isakovics, Monticello, N. Y., is the local secretary.

The Iron and Steel Market.

There is little can be said of September as to distinct new developments; rather, the month has been distinctive in that forces which have been at work for several months have continued and have almost played out, bringing the situation to a point where distinctly new trends must come.

On the one hand, the long wait of buyers, particularly of pig iron, must be nearly over, and a distinct buying movement is measurably within sight. On the other hand, the long period—long for the American iron trade—of high pressure for deliveries of material without corresponding fresh buying is about over. After a run of thirty-two months of production up to the physical limits, the last three or four months without important fresh additions to orders, the machinery of production is just beginning to slow down, and the prospects are that the slowing down will be rapid.

If the simile be permitted, it may be said that from the beginning of 1905 to last May or June the engine has run at full speed, with a good fire under the boiler; in May or June the fire went down, and the boiler pressure began to decrease, but by using a longer and longer cut-off the speed of the engine has been maintained; what steam is left is being taken for the full stroke, and the speed can no longer be maintained.

The Bessemer department at the Duquesne steel works permanently ceased operations about Sept. 1, making way for the eighteen new open-hearth furnaces which are being built. About Oct. 1 the Bessemer department at Homestead will be closed for thirty days or more for repairs. Following this the Edgar Thompson plant will be closed for repairs and improvements. Other producers are to follow a similar course. Many blast furnaces have not been doing well, but have been kept in operation until a fitting time for relining. Some finishing departments have been run at reduced pressure for a month or two, but the steel has found ready use elsewhere.

It appears to be the general view in the trade that the year 1908 will be one of reduced production. This is extremely significant, since, barring the off year of 1904, there has been a rapid and fairly steady increase in production, as to pig iron, of about 2,000,000 tons a year, from a trifle under 14,000,000 tons in 1900, to about 27,000,000 tons in the current year. The years 1905 and 1906 were years of demand, fully up to capacity and showed a production, respectively, of 23,000,000 and 25,300,000 tons. Capacity has been increased, and further erection is in progress, so that were demand sufficient, 29,000,000 or 30,000,000 tons of pig iron could be made in 1908, and if, instead, production falls below 27,000,000 tons, as fully expected, there will be much idle capacity. Such a condition the American iron trade has never before passed through without heavy reductions in prices of all iron and steel products.

Some lines of finished product are sold up better than

others. In structural shapes, plates, and steel bars, the mills claim to be able to run well into next year, without additional buying and merely on contracts already made. In wire products the mills are less well sold up. In merchant pipe, sheet and tin plates, there is relatively little business ahead, and production will be reduced before the end of the year. Tin plate has felt the effects first, as since the closing of some mills for repairs in July, the old pace has not been resumed, and in September a few additional mills were closed.

While the lines of heavy tonnage, including rails, shapes, plates and merchant bars will undoubtedly be held as to price, even though there is a great decrease in demand, price weaknesses have already begun to develop in other lines. The shafting market has been very irregular for two months. Light plates have weakened within the past month. Base prices on merchant pipe are claimed to be maintained, but the premiums for early delivery have totally disappeared. The advance of a dollar a ton in wire products made Sept. 3 is not being maintained. Billets have declined, and of course pig iron continues the decline inaugurated in May.

Pig Iron.

Striking an average of all districts and all grades, pig iron has declined at least a dollar a ton during the month. Transactions have been very light, buyers feeling certain that still lower prices are in prospect, and delaying to the last possible moment. This has resulted in somewhat more extensive buying of small lots for prompt delivery. It is barely possible that the waiting game may be played too long, permitting a temporary spurt in activity to stiffen prices again, but this seems improbable.

Southern No. 2 foundry is openly quoted at $18, Birmingham, and can be had for less. For the first half of next year, $17 is openly quoted, while several months ago when the market for next year opened, sales were made at $18.50. The decline, therefore, is much more than the disappearance of premiums for early delivery. In the North, foundry pig iron has declined in all markets and can now be bought for $20, f. o. b. certain furnaces, or a shade less. A sale of 500 tons was made about Sept. 23, delivery guaranteed during September, at not over $20.60, delivered Pittsburg.

Bessemer pig iron has been scarce and the market has declined comparatively little. There has developed a remarkable shortage of ores of Bessemer grade, and this has affected the large steel interests as much as it has the merchant blast-furnace interests which buy their ore. Bessemer iron cannot be had at less than $22, valley, the old price for any early delivery.

Steel.

Several mills are actively soliciting new orders, although in the Summer there were few sellers, and in some of the sales made several months ago, deliveries have been poor. These mills are well scattered geographically, and quote on Bessemer billets from $27 to $28 at their works, and $28 to $29 on open-hearth billets. There are no sellers in Pittsburg or the immediate vicinity, and delivered Pittsburg billets can be quoted at $29 for Bessemer and $30 to $30.50 for open-hearth. There has been a decline of fully $3 a ton in billets since July.

Finished Material.

Wire products were advanced a dollar a [illegible] effective Sept. 3, making wire nails $2.05 per keg, base, in carload lots to jobbers, and plain wire $1.90. The new prices are being shaded by some jobbers and some mills are not quoting. It is probable that the advance was merely a strategic move, to protect contracts taken at the old figures.

Demand for merchant pipe has fallen off greatly, and good deliveries are obtainable at the base prices, whereas, two months ago contracts at these prices were taken subject to delay, guaranteed deliveries commanding a premium of $2 to $4 a ton. On line pipe the mills are busy closing up deliveries for the season.

A fair amount of structural business is coming up and the fabricating shops and structural mills are in better shape than other lines, being pretty sure of relatively full operation for several months.

The large plate mills appear to have enough business to run them into next year, but the smaller mills are anxious for tonnage. Steel car business has been practically nil for months, and the car plants can hardly run much beyond the first of the year on old business.

Iron bars are still easier and can be had at $1.65, delivered Pittsburg. Otherwise we quote prices unchanged and well held as follows, f. o. b. Pittsburg:

Structural shapes, $1.70 per 100 pounds for beams and channels, 15 inches and under.

Plates, $1.70 for tank quality.

Merchant steel bars, $1.60, base.

Common iron bars, $1.65, delivered Pittsburg, and $1.60, f. o. b. Pittsburg for Western delivery.

Sheets, 28 gauge, $2.60 for black, and $3.75 for galvanized.

Tin plates, $3.00 for 100-pound cokes.

The Danger of Overspecialization.

Dr. Leo Baekeland, [illegible] distinguished as the inventor of velox paper for photographical purposes, and as the chemical engineer who reduced the Townsend electrolytic cell to practice on a large scale in the new alkali and chlorine works in Niagara Falls, recently addressed the New York Section of the American Chemical Society on the danger of over-specialization. From this address we herewith give some extracts. The full address may be found on pages 845 to 854, Vol. XV., No. 648 of "Science."

Dr. Baekeland emphasized that we ought to consider all pursuits of life from a broad general standpoint. Even now, our educational system is "still much under the chilling effect of that cloud, which, during the Middle Ages, hid the light of true knowledge." A tendency has manifested itself to reform this antiquated system of education, but this tendency now "seriously threatens us with the pitfalls of the other extreme."

"Furthermore, the fact that scientific learning has found unceasing applications in the production of wealth has fostered the constantly increasing tendency for finding a scientific education or scientific pursuits a mere means of earning a living or making money." * * * But "such men once having decided to enter a scientific profession, soon become aware that the call is for specialists, and they were forced to specialize one thing or another by their employers, whether the latter were manufacturers, merchants, or even some educational institutions whom they served as teachers."

"What is worse, our own way of living shows beyond doubt that we all have undergone, more or less, the effects of over-specialization against which I have come to protest."

"Busily borrowing away like moles in the pursuit of our own little specialties, we are dizzily preoccupied with our specialized routine work. We lose the desire of coming out for a while into the sunlight of the world, to take a stimulating look at the grand view of nature and its inspiring unity. One moment while we are rather disturbed in our narrow sanctum because some Curie announces radium or radioactivity, or when some Ramsay upsets our orthodoxy by proclaiming the world's evolution of elements. We get fairly shocked when a Crookes speaks of the ultimate matter."

"Just to the same way as after shaking a bag of coals that weight and matter the constant or intermittent bumping during journeys may have a more powerful influence on the belief that gravitation, like all other energies, may be something that is [illegible] better [illegible] that gravitation, being the more stable of all energies, is the final energy

toward which light, heat and electricity tend to change. Who knows but that ultimately a less neglected study of gravitation may allow us a glimpse into the secret of the destiny of our universe?

"I admit, many of you will smile at these unorthodox hypotheses or conjectures. Yet, let me ask you: With what methods have we thus far measured any possible changes in weight? We have pinned all our faith, all our beliefs, on a mechanical instrument called a balance. A very delicate method indeed, if judged from our conceited one-sided standpoint of specialists. We are proud if we possess a balance which can weigh a one-hundredth of one milligram; we work ourselves into awe and admiration before an instrument such as the one I saw two years ago, which can detect a difference of a one thousandth of a milligram. A one thousandth of a milligram! How infinitesimally small such a weight appears to our limited conceptions; and yet, what a ponderous quantity this same weight becomes if we try to compare it with the mass of an electron.

"Our whole science of chemistry is based on the fundamental law of the conservation of matter as formulated by Lavoisier and accepted by us as an axiom. However, by what means has this law been verified, if not by balances more crude, more imperfect, than the clumsy instrument which can not weigh anything beyond 1/1,000 of a milligram? It is high time that science should discover a more delicate means for determining small weights than a mere mechanical balance; then, but only then, may we be able to demonstrate beyond doubt whether all the assumptions on which we base our chemistry are correct, or whether we simply have been building a whole science on false premises.

"While we are at this subject, let us continue this act of self-examination. When we speak of the descriptive part of the science of chemistry, when we describe any reactions, any compounds, any laws, we all refer these to phenomena which take place within an abnormally small range of temperature. Lately, Dewar opened our eyes to some unexpected phenomena which occur at very low temperatures; on the other hand, the electric furnace so ably manipulated by our regretted Moissan enabled him to establish many unsuspected facts at temperatures which our imperfect thermometric methods do not allow us to measure accurately. Yet, if we will drop for a moment our one-sided considerations and look upon everything in true proportions, we must admit that the range of temperatures within which we have studied natural phenomena is disappointingly small, as compared with the possible range of temperature of the universe.

"Not so long ago, chemists had no better definition for organic compounds than to designate them as those that were produced under the intervention of vital forces; inorganic bodies, on the contrary, were supposed to be made under the influence of ordinary physical forces. We all know since, how Liebig and Wöhler disposed of this mistake by the memorable discovery of the synthesis of urea from inorganic bodies. Nevertheless, many of us to-day are prone to think that the more delicate organic bodies, as, for instance, the constituents of the protoplasm, will never be obtained synthetically. These doubters point to the fact that as soon as we try to imitate these subtle, synthetic reactions which take place in the living cell we remain powerless to accomplish anything beyond splitting or simplifying the molecule. And yet, let me ask you, what are the laboratory methods with which we try to imitate the subtle biological processes? Heating, boiling, distilling, desiccation, precipitation, electric currents, every one of these barbariously destructive methods, with which we blast away at exceedingly delicate compounds: we might just as well try to imitate the melodious music of a Gounod by firing some dynamite cartridges between the delicate string of a piano.

"One sided as we are, we witness every day of our lives the fact that all vegetation accomplishes its processes of synthesis or assimilation under the indispensable action of light; nevertheless, thus far we have tried very little to avail ourselves of this powerful, yet delicate source of synthetic energy. Up till now photochemistry has scarcely been used for any other purposes but the art of photography.

"What have we done to utilize the effect of pressure in the study of natural phenomena?" * * * "And how about the element of time in chemical reaction?" * * *

CORRESPONDENCE

Utilization of Peat for the Generation of Power and the Production of Artificial Manure.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—With reference to your note on page 145 of your April issue on the utilization of peat, I am sending you copies of the reports prepared by Dr. Caro and me on the gasifying of peat with simultaneous production of ammonia.[1] Peat should not be looked upon solely as a new source of electrical energy, but other important general economical and agricultural considerations should be taken into account.

In agriculture in the United States the need of employing artificial fertilizers containing nitrogen is now manifest, and this need increases even more rapidly in the United States than in Europe. This is indicated by the figures of the imports of Chili saltpetre, which increased in the last five years from 185,000 to 374,000 tons. On the other hand, considerable quantities of ammonium salt were also imported in spite of the high protective tariff, since the home production did not meet the demand.

It is natural that farmers in the United States as well as in Europe do not like to depend in such a way on foreign producers. This is especially so in view of the fact that the producers of Chili saltpetre are in an exceedingly strong position as a result of their natural monopoly as well as of commercial trust formations. For this reason there should be a wide field in your country for utilizing new sources of nitrogen available in large quantities.

There are two such sources: the atmospheric air and peat, and the methods of utilizing these two sources supplement each other in a rational and interesting way. I have found, with Dr. Caro, that the gasification of 1 ton of peat yields 55 kg. of ammonium sulphate as by-product, while the main product, namely, 1,780 cubic meters of gas produced, yield 450 to 500 horsepower-hours. For the fixation of 1 kilogram of atmospheric nitrogen in form of calcium cyanamide 20-hp. hours are required. Hence the 450-hp. hours obtained from the gas would be sufficient for the fixation of 22.5 kg. of nitrogen, which are equivalent to the nitrogen content of 112.5 kg. of ammonium sulphate or 143 kg. of Chili saltpetre.

I should not omit that our analyses of samples of peat from the United States, and especially from Canada, show that there are in these countries large deposits of peat containing considerably more nitrogen than the peat which we have treated in this country. The content of nitrogen amounts in some American peat samples to 3 per cent, so that the output of ammonia will be correspondingly greater.

I will finally say that the very extended deposits of peat which exist in North America from Canada down to the Gulf of Mexico have hardly been utilized at all for industrial purposes, although they are to be found just at such places in the country where other natural sources of energy like water powers do not exist. They represent a wide and greatly promising field for the active work of electrical and electrochemical engineers in the United States for the best interests of agriculture and industry.

A. Frank.

Charlottenburg, Germany.

[1] See page 405 of our present issue.—Editor.

VIENNA MEETING OF THE IRON AND STEEL INSTITUTE

The Autumn meeting of the Iron and Steel Institute (London) was held on Sept. 23 and 24 in Vienna, Austria. The program of the meeting included visits to the chief iron and steel plants of Austria-Hungary. Just twenty five years had elapsed since the Iron and Steel Institute held their first Vienna meeting in 1882.

While the full report of the proceedings and discussions held at the meeting must be reserved for our next issue, we are enabled to give herewith abstracts of all papers presented at the meeting, from advance copies kindly forwarded to us by the secretary of the institute. The paper by Prof. Baron von Jüptner on the application of the laws of physical chemistry in the metallurgy of iron will be printed in full in one of our next issues.

The Austrian Iron Industry.

In a paper on the Austrian iron industry during the last twenty-five years, Mr. Wilhelm Kestranek, general manager of the Prager Eisen Industrie Gesellschaft and of the Böhmische Montan Gesellschaft, could point with pride to the way in which Austria-Hungary has been able to hold its own in the list of iron-producing countries and to the important progress made in this period.

To characterize in general the position of the iron industry, it is interesting to note that during the last twenty-five years the world's production of pig iron increased in value from about 340 million dollars to about 960 millions, while the value of the production of gold rose from 102 million dollars to 390 millions. The value of the pig iron produced represents at the present time about two and a half times the value of the output of gold.

The annual production of pig iron in Austria-Hungary is now about 1,900,000 metric tons (against 600,000 in 1882). In sketching the natural influences which determine the growth of the iron industry in a country, Mr Kestranek made the following suggestive remarks.

"It can be taken as an axiom that the development of the iron industry of a country, in relation to the consumption, depends more on the richness of its fuel resources than on an abundance of iron ore. Thus it is seen that countries, such as Sweden and Spain, which are rich in ore and poor in fuel, export the greater part of their output of ores to countries rich in fuel, and are, in proportion to their wealth in ore, only small producers of pig iron. Other countries, on the other hand, such as Great Britain, which depends to a large measure on the importation of iron ores, and Germany, which also has to import considerable quantities of ore, occupy a leading position. It is unnecessary to mention the happy United States, which rejoices in the possession of an abundance of ore and of coking coal, and for this reason naturally occupies the leading position.

"The quantity and quality of the iron ores are as important a factor in commercial competition in the iron industry of a country as are the number and condition of the soldiers of an army; while the fuel resources are for the iron industry what the generalship and armament are for such an army. Under otherwise equal conditions the superiority in training and equipment of any army are more efficacious at the present time than mere weight of numbers. It therefore appears to me that the quality and quantity of fuel available are more decisive factors in the industrial development of the iron trade of a country than wealth of ores.

"If I may further develop this comparison, it must be mentioned that the conditions of two combatants are also naturally influenced by other important circumstances, such as the existence of ramparts, or in other words, protective duties; further by the natural resources and financial wealth of the two competitors, which, in the case under consideration, is the demand of the home market. Finally, the fortune of war depends on whether the forces are kept free from disease. Such diseases, mostly of a contagious character, are strikes and the efforts of organizations to hinder production.

"As an example, I believe that the development of the British iron trade would have been far more successful if the introduction of technical improvements had not been hindered by the action of trade organizations."

The prosperity of the Austrian iron industry is principally impaired by the want of mineral fuel, and by the costly methods of transporting the fuel to the iron districts. Nevertheless the Austrian iron industry has been able to keep pace with other countries, chiefly for three reasons: sufficiently high protective import duties; the association of the iron works into a syndicate; and the concentration of the smaller works into larger units.

"Theorists express the opinion that protective duties and trade syndicates hamper technical progress, because they put into the pockets of those interested abundant profits without any trouble. Opposed to this view, the Austrian iron industry can, with pride, point out convincingly that such a theory is devoid of foundation, because they are always endeavoring to improve their works technically. The Austrian iron-works have utilized all the modern methods for economical working, although they have been naturally limited, because their plant and appliances require to be fitted to a great variety of manufactures, and must be designed to suit the proportionately small consumption of the country. The Austrian iron industry has, therefore, to avoid mere slavish imitation of the gigantic works in the United States, and has modified modern methods to suit the given conditions."

The most extensive application of electricity is found everywhere in Austria, mostly in conjunction with the blast furnace gas engineer, and also coke-oven gas engines for the generation of power, and, as an example, in Witkowitz a plant of this description of 5,700 hp. exists.

At the Austrian blast furnaces which yield 700,000 cubic meters of gas per hour, 263,000 cubic meters are used for blast heating, so that 527,000 cubic meters are available. Of this quantity, at the present time 358,000 cubic meters, or 68 per cent are utilized for boiler heating, and 34,000 cubic meters, or 6.5 per cent representing 12,000 hp. in gas engines, whilst the remainder of the gas is used partly for ore-roasting or in drying kilns, and partly drawn off unutilized. The Bohmische Montangesellschaft, which at present is utilizing blast-furnace waste gases on the most extensive scale, utilizes 23 per cent of the available gas in gas engines.

In the Austrian coke works, the coke ovens yield 86,000 cubic meters of gas per hour of which quantity the coke ovens themselves absorb 62,000 cubic meters, so that 24,000 cubic meters are available. Of this quantity 5,700 cubic meters, or 24 per cent, are utilized in gas engines, whilst the remainder is used for boiler heating.

The most complete application of electricity to the driving of rolling mills is in Teschen, where, not only the finishing, intermediate, and roughing trains, but also the reversing rolling mills are driven by electric motors.

Finally it is very interesting to learn that the Austrian steel works engaged in the manufacture of high-grade alloy steels, especially tool steel, have lately adopted the new electric furnace processes. Thus we find that the Poldihütte have adopted the Kjellin process, the firm Gebruder Bohler & Co. are introducing the Keller electric process, and the new Styrian cast-steel works of Danner & Co. employ the Héroult

[illegible] The Kestranek'sche Eisen und Stahlwerks Gesellschaft has [illegible] decided to adopt the Héroult process at their works in Ferlach."

In his concluding remarks Mr. Kestranek seemed to prefer a protest against the famous statement that the iron industry is either a prince or a pauper.

"If the producers of iron of the rest of the world in the coming, as in the past quarter of a century, should so considerably enlarge their homes and built up palaces, Austrian iron masters must moderate their pretensions and keep their dwellings within modest dimensions. They will, however, at all times endeavor to keep them swept and garnished, so that all who dwell in palaces can nevertheless at all times enter them with pleasure, and they themselves will take no less pride in their homes than the dwellers in palaces."

Determination of Blast Furnace Gas.

A paper by Prof. Josef von Ehrenwerth described a simple method for determining the total quantity of blast furnace gas for a given make and its calorific value. The data required by this method are:

1 The weight of carbon contained in the gases corresponding to any particular unit weight of make. Say 100 kilograms.

2 An analysis of the gas expressing the constituents usually determined, in percentage volumes.

The first of these quantities, the carbon in the gases (C_G), corresponds to the total carbon (C) in the materials charged into the furnace, *i. e.*, carbon in fuel, and that in carbon dioxide contained in limestone flux or uncalcined carbonate ores, diminished by the amount (C_1) absorbed in carburizing the metal, and that (C_2) in unconsumed fuel carried away by the gas and intercepted in the dust-catcher, or

$$C_G = C - (C_1 + C_2).$$

The total volume of the gases may be computed from the heat balance sheet of the furnaces, where, however, they are expressed in weight, and no allowance is made for carbon in flue dust.

The analyses of the gas should include determinations of carbonic acid, carbonic oxide, light and heavy hydrocarbons and nitrogen, together with hydrogen on account of its high specific volume, although the weight is usually unimportant. The calculation depends upon the simple proposition that the ratio of the volume of gas produced per unit of make to that of the analysis (100 volumes) is the same as that of the carbon contents of these quantities.

Supposing the analysis to show the constituents and their corresponding volumes to be

$$aCO_2 + bCO + cCH_4 + dC_2H_4 + eH + fN = 100,$$

the carbon contained per 100 cubic meters in kilograms will be* $C_g = 3/11 \times 1.978a + 3/7 \times 1.252b + 3/4 \times 0.559c + 6/7 \times 1.16d = 0.539a + 0.537b + 0.419c + 0.994d$

Or in round numbers:

$$C_g = 0.54\ (a + b) + 0.42c + 1.00d.$$

The corresponding volumes of the different constituents per 100 units of make will then be found from the following proportions:

$$\text{For } CO_2 \text{ in cubic meter} \quad xCO_2 = \frac{C_G}{C_g} a$$

$$\text{For } CO \text{ in cubic meter} \quad xCO = \frac{C_G}{C_g} b$$

and so on for the remaining constituents.

Or, in general, the volume of gas in cubic meters per 100 units make

$$= \frac{C_G}{C_g}(a + b + c \ldots)$$

of the volumes per cent by analysis.

In the same manner the total quantity of gas is given by

$$G = \frac{C_G}{C_g} 100.$$

The results found by calculation are for the gas in the dried state, and require to be corrected for the water vapor derived from damp materials in the charge if necessary; and the volumes found are expressed at normal atmospheric pressure and a temperature of 0° C.

The calorific value per cubic meter at 0° and 660 millimeters is $W = 30.63\ CO + 80.000H_4 + 140C_2H_4 + 26.2H$ calories, the gas being supposed to be free from water.

The following example illustrates the use of the method. A blast furnace making white forge iron, with charcoal, from spathic ores (two-thirds calcined and one-third raw) consumed 74 kilograms of fuel per 100 kilograms of metal produced. What is the total volume of gas?

The charcoal contained C, 85.1; CO_2, 3.26; CO, 1. 36; CH_4, 0.7 per cent. or carbon in 74 kilograms, $62.97 + 0.66 + 0.43 + 0.38 = 64.44$ kilograms.

Carbon of CO_2 in raw ore.....	4.54
Total carbon in materials charged.....	$C = 68.98$
Carbon in metal.....	3.12
Total carbon in gases.....	$C_G = 65.86$

The gases contained: CO_2, 15.3; CO, 25.6; CH_4, 0.7; H, 1.3; N, 57.1 per cent by volume. $C_g = 22.29$.

$\frac{65.86}{22.29} \times 100 = 295.47$ cubic meters per 100 kilograms, or 2054.7 cubic meters = 104,350 cubic feet per ton.

The calorific value is $30.63 \times 25.6 + 86 \times 0.7 + 26.2 \times 1.3 = 784 + 60.2 + 34.1 = 878$ calories per cubic meter, or 98.4 British thermal units per cubic foot.

Economic Distribution of Electric Power from Blast Furnaces.

This problem was discussed in a paper by Mr. B. H. Thwaite (London). The author first called attention to the fact that the last unfinished link in the electrification of iron and steel works—the electric harnessing of heavy rolling-mills—has now at last been forged.

The heat and power efficiency of existing rolling-mills is deplorably low. Now that it is realized how valuable, as a power agent the blast-furnace gas has become, the waste of fuel is morally and financially inexcusable.

The objection that is advanced against the gas-power electrification of the rolling-mills relates to the heavy expenditure involved in such a technical reform. The objection is a real one, and unless removed or reduced, will tend to confine the advantages of application to firms of immense financial resources.

The basis of the program of the author is to pool the waste furnace gases from all the furnaces of an iron-making district independently of the ownership of such furnaces. The energy (electrically transformed) of the different furnaces would be transmitted to a central distributing and transforming station in which the current would be transformed to the voltage to satisfy different customers. Of course, there may be cases where the furnaces are so concentrated as to justify the delivery of the *furnace gases* to a pooling or central station for conversion into electrical energy, but usually it would be found to be more practical to transform the gas into electrical energy on the site of the ironworks for transmission to a distributing central station.

* This follows directly from the fact that 1 kg.-molecule of any substance (for instance, 44 kg. CO_2) fills 22.4 cm. under standard conditions of temperature and pressure.

The first call on this power would, of course, be the satisfaction of the internal demands of the iron and steel works, the balance of power remaining being available for external distribution over a wide area. The pooling program would be provided by a separate and distinctive joint stock electric power organization.

Instead of selling electric power to outside customers, the author considers the establishment of electrochemical and electrometallurgical industries, like the production of high-class steel from selected scrap, special alloys, such as ferro-silicon and ferro-titanium, ferro-chromium, besides the production of carbides (silicon and calcium). The production of calcium carbide is considered by the author to be an ideal associate for an ironworks, because the agents of production are coke, limestone and electrical energy.

Finally the following objection is dealt with; namely, supposing the market for iron does not justify the manufacture of pig, and it became financially imperative to blow out the furnaces, what about the supply to the pooling station under these circumstances. The author has solved this difficulty by designing a generator that, harnessed to the furnace-gas cleaning plant, produces gas of more or less exactly the composition of furnace gas.

The combustible portion of a typical example of this gas is chemically constituted as follows:

	Per Cent.
Carbon monoxide	32.4
Marsh gas	0.4
Hydrogen	1.6

The cost of this apparatus is small, because the cleaning plant and associated gas mains are those installed for the furnace gas. Such a generator of the generating capacity of the pooled gas proportion from a given furnace would be available within three hours' notice, and the simplicity of the apparatus makes the question of depreciation during stand-by periods of little or no economic importance. The fluid slag from this generator can be readily converted into slag wool. This furnace type of gas generator, designed by the author, is being adopted by one of the most important of continental iron firms to compensate for the vagaries of furnace output. It was illustrated on page 262 of the *Journal of the Iron and Steel Institute*, 1906, No. III.

Ageing of Mild Steel.

Mr. C. E. Stromeyer followed up his recent fifty five page paper, which was abstracted on page 264 of our July issue, with another paper of twenty-three pages and numerous tables of microphotographs.

His researches have not yet revealed the test which will discriminate between reliable and treacherous qualities of steel. Bending tests of samples with sheared edges seem to be of no scientific value. Bending tests of samples with planed edges are even less useful. Bending tests of samples having planed and nicked edges seem to be the best tests yet devised for studying ageing qualities, but the injury done to the various plates by nicking, which is revealed by bending, does not appear to discriminate between plates which have high or low percentages of phosphorus, sulphur, etc., nor between those which have, and those which have not, behaved well in practice. The bending of nicked samples is therefore in this respect no better than the ordinary tensile, temper, and cold-bending tests.

The brittleness, revealed by the bending of nicked samples, more especially if the plates are maintained at a fairly high temperature, as in boilers, suggests that calking, particularly that injudicious calking which grooves the underlying plates, may initiate a local brittleness, which, after a time, might endanger the boiler if severely stressed. This may account for the explosions which were formerly so common amongst locomotive boilers having single-riveted lap joints, for at these joints the cylindrical form is replaced by a zig-zag form, and instead of the simple tension stress there are locally very intense bending stresses. These experiments would also suggest that the practice fairly prevalent on the Continent of Europe, of resorting to frequent hydraulic tests, which, of course, produce much higher stresses than those to which boilers are subjected to while working, may cause fractures.

The heating of structures which are severely stressed by other means than by nicking, may create a brittleness which may ultimately lead to fractures. At any rate the author's experience among marine engines is that crank-shafts are far more likely to crack if they have been carelessly allowed to get hot, than if they have been always kept cool while running. On the other hand, long exposure to cold has a less injurious effect on nicked samples than storing them at ordinary temperatures.

As a matter of fact, the author's tests go far towards dispelling the not uncommon belief that prolonged and intense cold may cause some steels to become brittle. The reverse is rather the case; for, according to the author's experiments, prolonged exposure to heat, and not to cold, tends to make mild steel brittle.

"For fear that these remarks may lead to a misunderstanding, it is desirable to mention here that there is nothing in these experiments to show whether mild steel is more or less brittle when cold than when hot, and that on this point one has to be guided by experience, according to which rails are known to snap more frequently in cold weather than in warm, and that boilers have practically never failed by cracking when in use. Explosions are due to other causes."

A New Iron Paint and a New Application of Calcium Chloride from the Pickling Process.

A paper by Mr. F. J. R. Carulla refers to the utilization of the ferrous chloride, which is obtained from pickling iron and steel rods or plates in hydrochloric acid. The chloride waste pickle liquors are generally dealt with by adding some base, which, combining with the chloride, will precipitate the iron as an oxide, and that which naturally suggests itself is lime. But the calcium chloride produced thereby is also a very soluble and deliquescent substance, with little use for it, so that "he process can only be resorted to as a necessity. Certainly the calcium chloride solution might be run away, but a better use might be to employ it for watering roads and preventing the dust arising from the passage of motor cars, a use to which this salt is said to have been successfully applied."

Dr. C. F. Wulffing has suggested to use ammonia to effect the precipitation. The value of the ammonium chloride, thereby obtained, is greater than that of the ammonia employed, but the main object is to obtain a black oxide of iron. This, however, is only produced after long exposure to air blast in the presence of ammonia and naturally the operation involves difficulties.

The volatile nature of ammonia requires special attention to be given to the apparatus which must necessarily be closed. In view of the necessity of an air blast some of the ammonia will be carried off by the air, and provision has to be made in the plant not to lose this ammonia.

The oxide which is obtained "has a beautiful blue-black color, is quite insoluble in water, and which passed into the filter press leaves a clear solution of ammonium chloride, which is evaporated and allowed to crystallize. The blue-black iron oxide precipitate is magnetic, showing it to be Fe_3O_4, and is a valuable addition to the list of pigments that can be employed with advantage for the production of structural iron work." With the use of other bases instead of ammonia, it is not possible to obtain an oxide of equal quality.

Structures which have been painted with this blue-black oxide of iron (said to be used instead of being used in the preparation of the paint) are said to have kept fresh, though exposed to the weather for nearly two years, still showing a varnish-like surface. The Sharples Chemical Co., Ltd., are putting up a plant in Derby to work this process.

Case Hardening.

The process of case hardening consists in adding such a percentage of carbon to a relatively thin outside layer of iron or mild steel, as will, on correct quenching, produce a hardened surface, while the inner core of the metal still retains its initial character. Mr. G. Shaw Scott, in a paper on this subject, remarked that "case hardening is fundamentally the same as the older process of cementation, the chief points of difference being that in case hardening, a different carbon-conveying material is used from that generally employed in cementation, whilst in the latter process the carbon is allowed to penetrate through, or nearly through, the bars, and is not interrupted so at to form merely a surface or "case" of carburized metal

"Case hardening is somewhat allied to the Harveyizing and Krupp processes, both of which are employed for the hardening of armor plate.

"In the former process a solid carbonaceous cementing material is employed—usually charcoal; and in the latter a gaseous hydrocarbon is stated to replace the charcoal."

Mr. Scott's experiments were made with a variety of steel which is considered by the trade as specially suitable for case hardening, its composition being 99.16 per cent Fe, 0.14 C (combined), 0.01 Si, 0.08 S, 0.03 P, 0.58 Mn.

Of case-hardening mixtures were tried burnt leather (several varieties), wood charcoal, anthracite, sugar-charcoal, mixtures of barium carbonate and wood-charcoal, etc. Burnt leather was employed as the standard material, its composition being 77.80 per cent C, 3.20 N, 13.44 moisture, 5.56 ash.

Treatment of the test bars at 700° C. for 4 hours showed that absolutely no carbon penetration had taken place. A slight penetration—to the depth of 0.13 millimeter—was observed after similar treatment at 800° C., while at 900° C. the depth of carbon impregnation had increased to 1.58 millimeters.

Tests with different case-hardening materials and for different periods of time, but all carried out at 900° C., gave the following results:

Time of Heating.	*Burnt Leather "A."*	*Wood Charcoal.*	*Barium Carbonate and Wood Charcoal.*
2 hours.....	1.15 mm.	0.72 mm.	1.36 mm
4 "	1.58 "	1.07 "	2.20 "
8 "	2.30 "	1.58 "	2.84 "
12 "	2.80 "	1.80 "	3.17 "
16 "	Right across specimen.		

The table shows that the most rapid penetration took place with the mixture of barium carbonate and wood-charcoal, while the least penetration resulted from the use of charcoal.

All the case-hardening materials in common commercial use contain nitrogen, and the beneficial effect of nitrogen is discussed in the concluding part of Mr. Scott's paper. The following experiment is instructive: Two exactly similar bars of standard steel were selected. One was heated in an atmosphere of ammonia for 4 hours at 550° C. The other meanwhile received no treatment. Afterwards, both were heated in separate cast iron boxes in a non-nitrogenous carbonaceous material (sugar-carbon) for 8 hours at 1,000° C. The bars which had received no ammonia treatment gave a penetration figure of 1.44 mm., those which had been treated with ammonia 1.80 mm.

A microphotographic study showed "twinning" (twin-crystal formation) to be a result of the ammonia treatment. Since Osmond has shown that twinning can only result when iron or steel is in the gamma condition, the author concludes that nitrogen is to be added to the list of elements which cause iron to take or retain the gamma form. And since gamma-iron combines more readily with carbon than does alpha iron, this action of nitrogen on the iron would appear to sufficiently explain its beneficial effect during the early stages of the process of case hardening.

A second paper on the case hardening of mild steel was presented by Messrs. C. O. Bannister and W. J. Lambert.

The mild-steel bars tested were 1 inch in diameter and had the following composition: 0.080 C, 0.535 Mn, 0.018 Si, 0.059 S and 0.088 P. They were embedded in ordinary "red scintilla" and heated as follows: Four samples at 871° C. for 2½, 5, 10, 20 hours, respectively, and two samples at 982° C. for 48 and 120 hours. The times given here are the actual periods at which the bars remained at the temperatures stated, independent of the time taken in heating them up.

The authors first studied the microstructure of the cemented bars. Of the various microphotographs reproduced in the paper, one is specially interesting, showing a crack developed on quenching. This crack occurred exactly between the supersaturated portion (on the outside) and the saturated portion (inside). These quenching cracks, which are often a great trouble in case-hardened goods, are evidently due to the unequal contraction of the portions containing different amounts of carbon on quenching.

The microstructure, showing the crack, belonged to the test bar, which had been heated for 120 hours at 982°. The same bar was later subjected to analysis at different places. The outside portion, keeping well clear of the dark etching band, contained 1.37 per cent C, the middle of the dark etching band contained 0.90, towards the center, and well clear of the dark etching band, the percentage of carbon was 0.25, while in the center portion it was 0.13.

Very great care was taken to detect any trace of graphite carbon present, but the whole of the samples were soluble in dilute nitric acid, showing that graphite was not present. This is probably due to the fact that the temperature was kept below 1,000° C.

For the determination of the depth of carburization, the prepared surfaces of the soft specimens were measured to obtain the depth made evident by etching, and for the file-hardness test the hardened specimens were carefully ground down on a rotary grinding machine, the file being tried after the removal of each 1/1000th of an inch from the side. In the following table, which gives the results, the first line gives the time of case hardening in hours, the second line the temperature in degrees C., the third line the depth, in inches, of cementation measured by etching in soft specimens, and the fourth line the depth, in inches, of file hardness in hard specimens:

Hours of hardening..	2½	5	10	20	48	120
Deg. C. of hardening.	871	871	871	871	982	982
Inches	0.020	0.030	0.039	0.052	0.108	0.236
Inches	0.015	0.020	0.023	0.027	0.090	0.095

The authors consider that the "solid-solution theory" is capable of offering a satisfactory explanation without bringing in the question of the formation of sub-carbides, etc. Thus in the four bars which were carburized at 871° C. the carbon penetrated the bars until they became saturated, that is, contained 0.9 per cent of carbon, and very little diffused as a more dilute solution than this, as shown by the very narrow ring of carburized metal within the saturated portion.

On the other hand, the bars carburized at 982° C. were supersaturated on the outside with the formation of free Fe_3C, and at this highest temperature the carbon was also capable of diffusing more easily as a dilute solution, as evidenced by the wider range of carburized metal within the saturated portion.

Hardened Steels and Metallography.

A suggestive paper on hardened steels by Mr. Percy Longmuir, of Sheffield, begins with the following paragraphs:

"The ultimate test of a hardened steel is its working life as a tool, and whilst it may not be difficult to obtain the requisite hardness, it is difficult to obtain it with freedom from clinking or cracking, from brittleness or rottenness and from warping. The hardness test alone is therefore insufficient, and the non-recognition of this fact in the literature of hardening is to be

regretted. This is not, however, the only omission, and, generally speaking, the literature of hardening bears very little relation to the practice of hardening. As a result, practical men view with distrust researches on hardening, especially when founded on results deduced from microscopical examination. So much is this the case that the microscope is regarded by many competent workers as having hopelessly failed to be of service in the case of hardened steel.

"As a matter of fact, no metallographical investigation yet published has been of the least service as a guide to the thermal treatment of high-speed steels, and with few exceptions comparatively little information of value has been given on the hardening or tempering of carbon steels. These statements do not necessarily imply the condemnation of the microscope as a practical aid in the study of hardening, but rather emphasize the difficulties of interpretation, and also the fact that many scientific workers are unfamiliar with the practical aspects of work. This divergence between practice and theory has naturally led to controversy; but ignoring controversial questions as far as possible, an effort is made in the following paper to indicate briefly some variables in the case of carbon steels.

"The suitability of a quenched steel is a function of the carbon present, and so firmly is this recognized in practice that special care is always exercised to obtain the exact percentage which experience has indicated as being desirable. The usual range is from 0.5 to 1.5 per cent of carbon, but in special cases the latter figure is exceeded. The first essential, that of a suitable percentage of carbon, is most rigidly adhered to. Other features calling for note are as follows:

(1) The majority of articles for subsequent hardening are worked into shape from rod, string or strip, which in turn has undergone a considerable amount of work in reduction from the ingot. Only in exceptional cases are cast materials submitted to hardening.

(2) Whilst heating, temperatures may reach 1,000 C.; quenching temperatures never attain this point, and the usual practice is to quench at as low a heat as is consistent with the properties desired in the tool.

(3) Quenching baths, when of plain water, are usually aired, but never fall below atmospheric temperature.

(4) After water hardening, the majority of tools are tempered.

"In well organized works the processes of hardening and tempering are operated by specially trained workers, who achieve results of remarkable regularity. The practice of hardening is in a more advanced state than is realized by many scientific workers. As an example, a skilled hardener will harden and temper 7 gross of high-quality pocket knife blades per day of 9 hours. The tang of the blade is not hardened, but the full length of the blade must be hard. On spite of the rapidity of work, wasters due to faulty hardening are practically nil. Further, blades of like kind hardened by one man are, on microscopical examination, found to give regular structures which do not vary in different sections of one blade, nor yet do they appreciably vary from blade to blade. Similar conditions hold in the general cutlery and tool trades. Hardening operations are remarkably effective and, notwithstanding large outputs, very free from waste.

"Several works personally known to the author engaged on most intricate hardening of a non-repeat character, have losses falling well below 1 per cent. In view of the variety of work handled, of every possible contour, and ranging in weight from less than an ounce up to 300 pounds the results obtained bear good testimony to the skill of the hardening personnel.

"However, notwithstanding the success achieved in hardening practice, there is still room for improvement, and when occasionally erratic results occur the natural object is to endeavor to ascertain the cause with a view to avoiding it in the future. Under these conditions practice, of necessity, has to rely on its own empirical experience."

In discussing the microstructure of commercially hardened steels the author arrives at the following important results: "The characteristic feature of a correctly-hardened steel is an absence of definite or pronounced structure, whereas, the leading trait of a spoiled steel is the presence of a definitely sharp structure."

The ideal condition represented by a lack of structure is obtained only in a certain range of quenching temperature, which varies according to the composition of the steel and the contour of the piece to be hardened. Temperatures outside this range result in more or less crystalline patterns, which in the smallest of sections vary from field to field. Although certain of these patterns may give the appearance of special constituents they are in reality the product of an abnormal quenching temperature, and steels containing them, although hard, are useless for cutting or resisting abrasion.

"The diversity of structure in normal and abnormal products quenched under unsuitable conditions explains to some extent the attitude of practical men towards the microscope, but instead of leading to condemnation it should rather lead to recognition of the value of microscopical examination. Diversity indicates wasters, whilst uniformity denotes correct hardening conditions. Working on these lines the author has found the microscopical examination of hardened steels of great assistance in the solution of problems met with in hardening practice."

The paper is concluded by the following remarks:

"The discrepancies in the literature of hardening are due to the fact that certain essential practical features have not met with recognition. Thus any hardened steel, previous to hardening, must have had a considerable amount of mechanical work put on it. Any mechanical stresses present must be relieved by annealing. If the properties of a hardened tool depended solely on the production of a certain type of structure, then cast tools would answer. Experience shows that the fullest properties are only reached on material which has been worked and annealed. Recognition of these features and a study of advanced hardening practice would result in the removal of many discrepancies and tend to elevate metallography into a science from which practical men could draw inspiration in times of difficulty."

A second paper on the hardening of steel had Mr. L. Demozay, of Paris, as author. Since the results obtained in practice during the hardening of steel depend on the conditions under which the transformations of the metal take place, and particularly on the duration and the temperature of the heating, the energy of the quenching bath and the size of the pieces quenched, the author endeavored to analyze the part played by each of these different factors. The tests were made with samples of special nickel-chromium steel, and the results are given in numerous diagrams and tables.

With respect to the general conclusions the results are of a qualitative nature only. As to the heating operation, it is pointed out that the transformation point of a steel varies within two temperatures. The maximum value would be the temperature of transformation at the center of a very small sample rapidly heated to a high temperature. The minimum value would be the temperature of transformation at the surface of a large sample very slowly heated to a comparatively low temperature.

As to cooling, the point of transformation on cooling varies in a steel between two extreme temperatures. The maximum value would be that of the transformation of a point on the surface of a large sample slowly cooled. The minimum value would be that of the transformation at the center of a small sample rapidly cooled.

The effects of changing the size of the sample, of changing the temperature and of considering different points within the samples—other things being equal—are also given in general statements.

Steel and Meteoric Iron.

Prof. Eug. Berwerth's paper, which had been prepared with special reference to the celebrated and truly incomparable meteorite collection in the Imperial Natural History Museum in Vienna was exceedingly suggestive by showing in a general way that meteoric iron and steel-works steels are results of essentially similar chemical and physical causes. Meteoric irons may, in their essentials, be properly included in the category of steel. The fundamental difference is that while artificially-produced steels are mainly iron-carbon alloys, meteoric iron-steel is an iron-nickel alloy with meteoric carbon.

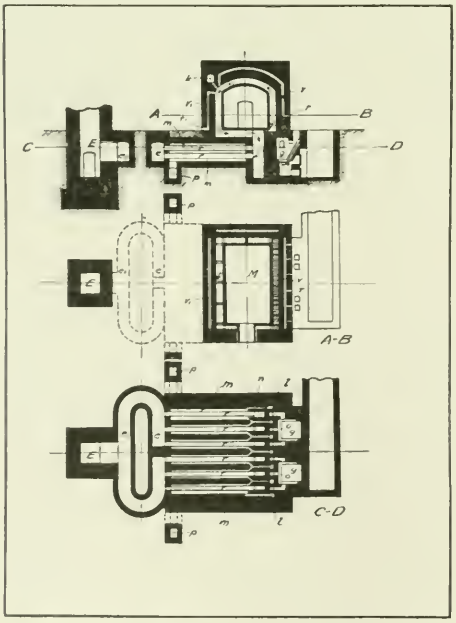
The Erzberg of Eisenerz.

The Erzberg (ore mountain) of Eisenerz (iron ore) was the subject of a paper by Prof. H. Bauerman who discussed the geology of this important mineral deposit of the Eastern Alps and sketched the mining and metallurgical undertakings connected with this deposit.

Producer Gas-Fired Muffle Furnaces.

By Oskar Nagel, Ph. D.

In coal-fired muffle furnaces the combustion products escape at very high temperature after heating the muffle, which means a considerable loss of heat. Producer gas firing is much more economical in such a furnace, as the waste heat can be used advantageously for preheating the combustion air. Furthermore, the sensible heat of the brick walls can also be utilized for preheating air by providing suitable air slots.



Figs. 1, 2, 3.—Producer Gas-Fired Muffle Furnace.

Figs. 1, 2 and 3 show a producer gas-fired muffle furnace. Fig. 1 shows a vertical section, Fig. 2 a horizontal section through the muffle proper, Fig. 3 a horizontal section through the recuperating apparatus.

The furnace shown in the illustration is provided with two producers *g*. The gas goes through openings (*O*) into the fire space (*f*) surrounding the muffle. At the entrance the gas is mixed with hot air, which is led to these points through channels (*l*) between the gas channels from the recuperator. The gas flame rises upwards, plays around the muffle arch and goes downward, heating the bottom of the muffle. Then the products of combustion—still very hot—go through pipes (*r*) to the flues (*cc*) leading to the stack. The pipes (*r*) are built into the wider channels (*m*), into which air is led through channels (*p*). This air plays around the pipes (*r*) opposite to the flame direction, and is heated by absorbing through the pipe walls the heat of the combustion products. The highly preheated air finally goes through channels (*n*) into pipes (*l*), which lead to the fire space and are arranged between the gas pipes.

For effecting a uniform heating of the muffle, the producer gas can be led into the fire space also at a second and third place and the sensible heat of the brick walls utilized for preheating the air necessary for oxidizing this quantity of gas. In the construction shown in the illustration, at half the way of the fire gases around the muffle, producer gas and preheated air is again allowed to enter. The air necessary for burning this gas enters at *t* and *t* through openings regulable by slides into the air slits *v v*, arranged behind the fire-brick wall of the furnace. The producer gas entering at the second place is also taken from the producers *g*.

Metallurgical Calculations.

By J. W. Richards, Ph. D.,
Professor of Metallurgy in Lehigh University.

The Electrometallurgy of Copper.

The electric current is used in metallurgy either for its electrolytic effects or for its electrochemical action. In the former the property of the current utilized is its ability, when passing in one direction through an electrolyte, of causing at the cathode a *reducing* action, such as the separation of metal from the electrolyte or the reducing of a ferric salt to a ferrous salt, and at the anode a *perducing* effect, the direct opposite chemically of reducing, such as the taking of a metal into the electrolyte or the perducing of a ferrous or cuprous salt to the ferric or cupric condition. In such a process heat is inevitably generated to some extent by the passage of the current through the ohmic resistance offered by the electrolyte. The extent to which heat is thus generated, coincident with the electrolytic action of the current, is of no significance whatever upon the nature of the process, which remains essentially *electrolytic* as long as the current is used for and performs its electrolytic decomposing function. However, when the heat thus coincidently and inevitably generated in the operation of a process essentially electrolytic, is sufficient to keep melted an electrolyte which is not liquid at ordinary temperatures, the apparatus as a whole may not improperly be regarded as a furnace, and is very properly classed as an *electrolytic furnace*.

Electrochemical processes are those characterized by the absence of electrolysis, as shown by the arrangement and working of the apparatus, use of alternating current, etc., and in which the current is used solely for its heating effect. Such processes are carried on in *electric furnaces*, and are essentially processes in which chemical reactions or physical changes are brought about in the charge solely by the action of the temperature maintained by the assistance of the electric current. Metallurgically, the furnaces used are resistance furnaces, arc furnaces and combinations of the two. In resistance furnaces the heat operating the furnace is produced by the resistance either of the substance or charge itself, or by the resistance of a solid, liquid or granular resistor, intermingled with, in contact with, or placed in the neighborhood of the material to be

heated. In arc furnaces the current jumps a gap between two poles and generates locally the very high temperature of the arc, which is utilized by feeding the material to be treated into it or by bringing in close proximity to it. In the combined arc-resistance furnace, the material being treated forms one or both poles of the arc, and is therefore heated by the arc itself as well as by the passage of the current through its own substance.

In electrolytic processes the output of material, or commercial efficiency of the process, is essentially dependent upon the amperage of the current, since electrolytic effects are proportional to the amperes passing through the electrolyte. In electrochemical processes the commercial efficiency of output will vary with the total energy dropped by the current in the furnace, *i. e.*, will be proportional to the watts of current used up, not to its amperage or voltage, but to the product of these. Direct currents only are employed in electrolytic processes; direct or alternating may be used in electrothermal processes, but alternating are preferred, because of the complete absence of one-sided electrolytic effects when they are used.

Assuming familiarity with the ordinary non-electric metallurgy of copper, we may divide the electrometallurgy of copper into the following classes:

I. Electrolytic processes—
   1. Direct treatment of ores.
   2. Treatment of matte.
   3. Extraction from solutions.
   4. Refining of impure copper.

II. Electrothermal processes—
   1. Direct smelting of ores.
   2. Melting and casting of copper.

I.

Electrolytic Processes.

Copper has an atomic weight of 63.6. It occurs chemically as cuprous compounds, formulæ $Cu.A^{I}$, or cupric compounds, formulæ $Cu.A^{II}_2$, where A^{I} is a univalent or monad acid radicle and A^{II} a bivalent or dyad acid radicle. As a monad atom, copper has a chemical equivalent of 63.6, as a dyad element 31.8. The amounts of copper dissolved into or deposited from a cupric or cuprous salt are proportional to the chemical equivalent of copper in these two states and to the amperes flowing. Assuming that 1 amp. liberates electrolytically 0.00001036 grams of hydrogen per second, we will have as the amount of copper concerned in the passage of 1 amp. through one tank:

	Cuprous Compounds.	*Cupric Compounds.*
1 Ampere, per second...	0.0006589 grams.	0.0003295 grams.
per minute...	0.03953 "	0.01977 "
per hour.....	2.372 "	1.186 "
per day.....	56.93 "	28.46 "
per year.....	20.78 kilograms.	10.39 kilograms.

A useful datum to remember, if one is used to working in English measures, is that 1 amp. deposits practically 1 ounce avoirdupois (28.35 grams) of copper per day in each cell, using cupric compounds, and 2 ounces for cuprous compounds, or respectively, one-sixteenth and one-eighth of a pound per day. These figures are, of course, the theoretical figures for an ampere efficiency of 100 per cent.

I. 1—Treatment of Ores by Electrolysis.

There are no native ores of copper susceptible of being melted and electrolyzed—in the manner, for instance, that sodium nitrate (Chili saltpeter) can be melted and electrolyzed for the production of sodium. The most abundant ore of copper, its sulphide, occurs mostly mixed with several times its weight of foreign material, and even if picked out pure and melted it redissolves copper at the cathode so actively that no electrolysis is possible. Faraday showed that melted cupric oxide is decomposed by the current, and if the oxides of copper were found anywhere in sufficient purity and quantity they could be melted and decomposed electrolytically, but hardly in any case as cheaply as they could be reduced by carbonaceous material.

Cupric chloride is found in nature as atacamite, with the formula $CuCl^2.3Cu^2O.2H^2O$, in a comparatively pure condition, but in small quantity, in Chili. Such material will dissolve in considerable quantity in melted salt (NaCl), and can then be electrolyzed. The dissolved copper salt is first reduced by the current, with evolution of chlorine, to CuCl, and then this decomposed. The quantity of this material is at present insignificant, but there is a possibility of an electrolytic process along this line.

Cuprous chloride does not occur in nature, but can be readily made from other copper-bearing material. Chlorine gas, for instance, converts the common copper sulphide, Cu^2S, into CuCl (Ashcroft's process). When melted, cuprous chloride conducts the current very well, copper separating out as fine leaves. The melt cannot be heated to the melting point of copper and the copper obtained liquid, because it vaporizes too easily. It is a good conductor, its resistivity at 50° above its melting point being only 6 ohms (per centimeter cube).

Problem III.

In electrolyzing a bath of melted cuprous chloride, using an unattackable anode, the electrodes are 5 centimeters apart, and a current density of 2 amperes per square centimeter is used.

Required:

(1) The voltage required for running the bath.

(2) The proportion of the energy of the current converted into heat.

(3) The volume of chlorine, at 0°, liberated per minute by a current of 1,000 amperes.

(4) The output of copper in kilograms per kilowatt-hour of electric energy employed.

Solution.

(1) The voltage required includes that necessary to overcome the ohmic resistance of the electrolyte plus that absorbed in chemical decomposition. With a resistivity of 6 ohms, current density 2 amps. per square centimeter, and distance between electrodes 5 c. m., the first item is

$$V^c = 6 \times 5 \times 2 \div 5 = 12$$

The second item comes from the heat of formation, by dividing that heat expressed per chemical equivalent by 23,040. Since (Cu, Cl) = 35,400 Calories, we have

$$V^d = 35,400 \div 23,040 = 1.5$$

The total voltage required would be

$$V^c + V^d = 13.5 \text{ volts.} \quad (1)$$

This is independent of drop of voltage at contacts of electrodes with the conductors. That may amount to 0.5 or 1.0 volt, unless the contacts are very closely looked after.

(2) The current drops as sensible heat,

$$12 \div 13.5 = 0.8) = 89 \text{ per cent of its energy.} \quad (2)$$

(3) Assuming 100 per cent efficiency of liberation of chlorine, we have

Hydrogen gas liberated by 1 ampere in 1 sec. = 0.0001035 grams.

Chlorine gas liberated by 1 amp. per 1 sec.

$$0.0001035 \times 35.5 \div \text{Chem. eq. wt.} = 0.03674 \text{ "}$$

Chlorine gas liberated by 1000 amperes in 1 minute = 22.04 "

Volume of chlorine at 0° C.

$$22.04 \div (1.466) \div 35.5) = 6.9 \text{ litres.} \quad (3)$$

(4) One kilowatt, at 13.5 volts, gives 1000 ÷ 13.5 = 74 amperes.

This current, in one hour, would, at 100 per cent efficiency,

$$2.372 \times 74 = 175 \text{ grams of copper.} \quad (4)$$

Lower current densities would absorb less voltage and give a greater power-factor output.

I. 2—Electrolytic Treatment of Matte.

Matte is a mixture of Cu^2S with FeS, and frequently impure with Pb, Zn, Ag, Au, As, Sb, Ba, etc. It melts sharply at about 1,000° C., to a thin liquid; it sets quickly to a hard, stony mass. When melted it can dissolve copper rapidly, so that electrolysis results in the matte being re-formed as quickly as it tends to be decomposed, and it apparently conducts the current without decomposition. If it could be dissolved in certain other fused sulphides in small amount, such as in fused sodium sulphide, it could conceivably be electrolyzed continuously, but no process has as yet been developed along these lines. If it could be dissolved in aqueous solutions of alkaline or other sulphides, it might be electrolyzed in such solvents, but no successful solvent of this nature has been found. It is not impossible that some aqueous solutions may be found to answer this purpose.

Solid matte is conducting, and may be used as an anode or a cathode. When so used it is acted upon by the electric current, reducingly as cathode and perducingly as anode; that is, used as cathode it tends to be reduced *in situ* to metallic copper and iron, if there is any base present capable of uniting with and carrying away the sulphur; used as anode its copper tends to pass into combination with the acid radicle of the electrolyte, leaving the sulphur behind.

Use of Matte as Cathode.

Pedro G. Salom describes the use of this principle, called by him cathodic reduction, and has applied it on a large scale to the reduction of PbS concentrates, used as cathode in dilute sulphuric acid, to spongy lead. If the process is applied to granulated copper matte, assumed as nearly pure Cu^2S to simplify this discussion, the anode product is O^2 gas, and the cathode product H^2 gas mixed with varying quantities of H^2S. A. T. Weightman (Trans. Am. Electrochemical Society, II. [1902], 76) gives details of such an experiment.

Problem 118.

Fifteen grams of Cu^2S was used as cathode in a 5 per cent solution of H^2SO^4, using an unattackable antimonial-lead anode. A current of 3.6 amps. was sent through for 3 hours (voltage not given). Area of electrodes 50 sq. c. m. each, distance apart 4 c. m. Gases contained H^2 and H^2S in the following proportions:

	H^2	H^2S
At 5′	42.4	57.6
At 180′	90.8	9.2
Average 0–180′	79.5	20.5

Required:

(1) The voltage required to run the cell, if H^2S alone were liberated, 100 per cent pure.

(2) The voltage required to run the cell at the beginning, at the end, and the average throughout the run.

(3) The proportion of the Cu^2S reduced to Cu during the run.

Solution:

(1) The voltage to overcome ohmic resistance requires first the resistivity of the electrolyte, which for 5 per cent solution is 4.8 ohms. The ohmic resistance of the cell is, therefore,

$$4.8 \times 4 \div 50 = 0.38 \text{ ohm}$$

and the voltage drop to send 3.6 amperes through this

$$0.38 \times 3.6 = 1.37 \text{ volts.}$$

If H^2S were liberated pure, in which case the solution would be saturated with H^2S, the chemical reactions are

$$Cu^2S + H^2O = 2Cu + H^2S \text{ (gas)} + O$$

and the energy involved

(Cu^2, S)	= 20,300 absorbed
(H^2, O)	= 69,000 "
(H^2, S)	= 4,800 evolved
Sum	= 84,500 absorbed.

The voltage absorbed in producing this chemical reaction is:

$$\frac{84{,}500 \div 2}{23{,}040} = 1.83 \text{ volts}$$

The total voltage necessary to run the cell is

$$1.37 + 1.83 = 3.20 \text{ volts.} \quad (1)$$

(2) If no H^2S were formed, and the current liberated only H^2 gas, there would be absorbed in decomposition 1.50 volts, and by the cell as a whole 2.87 volts. Since a molecule of H^2S contains the same amount of hydrogen as a molecule of H^2, equal volumes of H^2S or H^2 would be liberated by an equal electric current. It follows, therefore, that at 5 minutes 57.6 per cent of the current was performing reduction, liberating H^2S and 42.4 per cent liberating hydrogen.

The principle here involved in calculating the voltage dropped corresponding to the chemical work done is that of the composition and resolution of voltages, explained by the writer in Transactions American Electrochemical Society V. (1904), p. 89. The numerical result desired may be reached in several ways, for instance,

$$1.83 \times 0.576 = 1.054$$
$$1.50 \times 0.424 = 0.636$$
$$V^d = 1.69 \text{ volts}$$

but, for conduction, $V^c = 1.37$ "

therefore, total voltage, $V = 3.06$ " (2)

At the end of the run we have similarly

$$1.83 \times 0.092 = 0.168 \text{ volts}$$
$$1.50 \times 0.908 = 1.362 \text{ "}$$
$$V^d = 1.53 \text{ "}$$
$$V^c = 1.37 \text{ "}$$
$$V = 2.90 \text{ "} \quad (2)$$

For the average running

$$1.83 \times 20.5 = 0.375 \text{ volts}$$
$$1.50 \times 79.5 = 1.193 \text{ "}$$
$$V^d = 1.57 \text{ "}$$
$$V^c = 1.37 \text{ "}$$
$$V = 2.94 \text{ "} \quad (2)$$

(3) Since 20.5 per cent of the current reduced copper during the run, the weight of copper reduced must have been

$$1.186 \times 3.6 \times 0.205 = 0.88 \text{ grams.}$$

But, the 15 grams Cu^2S contained, if pure,

$$15 \times \frac{127.2}{159.2} = 12 \text{ grams.}$$

Proportion reduced in the three hours

$$\frac{0.88}{12} = 0.073 = 7.3 \text{ per cent.} \quad (3)$$

This method of reduction of matte would need radical improvement before there could be any possibility of its commercial application.

Use of Matte as Anode.

This has appeared to many persons a hopeful application of electrometallurgy to copper. The matte is cast around some strips of copper, or copper netting is better, these giving the piece strength, preventing its disintegrating too quickly, and serving as conductors. Used in acidulated copper sulphate solution, the tendency is to dissolve out copper as copper sulphate and leave the sulphur as a residue. The latter is a non-conductor, forming an insulating layer, which increases greatly the voltage required to run the bath. Attempts to scrape off this layer are fruitless, because of the irregular,

cavernous corrosion of the anodes. Marchesi, an Italian, installed a plant to work this process near Genoa in 1882; a plant was also erected in Stolberg, Germany. Both were quickly abandoned as impracticable.

The theoretical reaction is for purest matte

$$Cu^2S = 2Cu + S$$

so that for four chemical equivalents of copper deposited one molecule of Cu^2S is broken up. The voltage corresponding to the chemical work done is, therefore,

$$\frac{20{,}300 \div 4}{23{,}040} = 0.22 \text{ volt.}$$

The voltage required by the cell is this plus that absorbed in overcoming the ohmic resistances of the circuit.

If the matte were only FeS, the reaction would consist in the solution of iron, sliming of sulphur and deposition of an equivalent amount of copper:

$$FeS + CuSO^4aq. = Cu + FeSO^4aq. + S.$$

and the energies involved are

(Fe, S)	= 24,000	Calories absorbed
(Cu, S, O^4, aq.)	= 197,500	" "
(Fe, S, O^4, aq.)	= 234,900	" evolved
Sum =	13,400	" "

and the voltage *contributed* to the circuit is

$$\frac{13{,}400 \div 2}{23{,}040} = 0.29 \text{ volt.}$$

If the matte is, as it usually is, part Cu^2S and part FeS, then when it is uniformly corroded there occurs a combination of the above two reactions. If the matte corresponded, for instance, to the formula Cu^2S. FeS, and these were simultaneously acted upon, the current would be divided in the proportions required by the preceding reactions; that is, twice as much to handle the Cu^2S as for the FeS. The voltages concerned will enter into the calculation in the proportions 2 to 1, and the calculated voltage of decomposition will be

$0.22 \times \frac{2}{3} =$	0.147 volt
$0.29 \times \frac{1}{3} =$	0.097 "
Sum =	0.15 "

The calculation can be made for any proportions of Cu^2S and FeS, remembering that every 159.2 parts of Cu^2S requires twice as much current as 88 parts of FeS.

Problem 112.

Marchesi erected and operated for some time an electrolytic plant using copper matte as anodes. The matte used contained 30 per cent copper, 30 sulphur and 40 iron, and the anodes measured 800 x 800 x 30 m. m., and weighed 125 kilograms. The cathodes were 700 x 700 x 0.3 m. m. The tanks were lead lined, with interior dimensions 2,000 x 900 m. m. x 1,000 m. m. deep. Electrolyte an acid solution of copper and iron sulphates. Resistivity assumed at 6 ohms. The plant contained 120 tanks, arranged in ten groups of twelve each, each group being run by a separate dynamo. Current density, 30 amperes per square meter of cathode surface; each tank contained twenty anodes and twenty-one cathodes. Conductors, 30 m. m. diameter; total length to one group 10 meters.

Required:

(1) The electrical current required by each group of twelve tanks and the motive power to run its dynamo.

(2) The rate at which the anodes lost weight per day.

(3) The rate at which $FeSO^4$ accumulates in the bath, in per cent of the weight of the bath.

(4) The output of copper per day.

(5) The length of time necessary to plate 1 c[illegible] of copper on one side of each cathode plate.

Solution:

(1) The first point to be solved is the voltage required per tank, and that consists of voltage absorbed by ohmic resistance and that of chemical decomposition. The first must be found from the ohmic resistance of the baths, the second from the chemical reactions involved.

With twenty anodes, each 30 m. m. thick, and twenty-one cathodes (the end ones against the ends of the tank) 0.3 m. m. thick, the thickness of electrodes in a tank is

$$(20 \times 30) + (21 \times 0.3) = 606.3 \text{ mm.}$$
$$60.6 \text{ cm.}$$

and the free space between, in the length of the tank, is

$$200.0 - 60.6 = 139.4 \text{ cm.}$$

Since this is divided into 40 spaces, the free space is

$$139.4 \div 40 = 3.5 \text{ cm.}$$

The total anode surface is, assuming them entirely immersed,

$$80.0 \times 80.0 \times 2 \times 20 = 256{,}000 \text{ sq. cm.}$$

and of the cathodes,

$$70.0 \times 70.0 \times 2 \times 20 = 196{,}000 \text{ sq. cm.}$$

giving current passing through a tank

$$19.6 \times 30 = 588 \text{ amperes.}$$

Since the tank is wider and deeper than the plates, the effective cross-sectional area of electrolyte is 25.6 sq. m. at the anode surface, 19.6 sq. m. at the cathode surface, and greater than either (by spreading of current lines) in between. It will not be far wrong, under these conditions, to take the effective area of the electrolyte as about that of the larger electrode, viz.: at 25.6 sq. m. The resistance of the tank thus becomes

$$R = \frac{6 \times 3.5}{256{,}000} = 0.000082 \text{ ohm.}$$

and the voltage absorbed in overcoming ohmic resistance

$$0.000082 \times 588 = 0.048 \text{ volt.}$$

During active corrosion, if copper and iron are dissolved in the proportions 30 to 40, this would be, in chemical equivalent proportions as $30 \div 31.8$ to $40 \div 28$

or as 0.943 to 1.429

since the current divides, in doing mixed electrolysis, in proportion to the number of chemical equivalents dissolved or deposited. It thus results that $0.943 \div (0.943 + 1.429) = 0.4 = 40$ per cent of the current is dissolving copper and 60 per cent dissolving iron. The corresponding voltage of the chemical work is, therefore,

$0.22 \times 0.40 =$	0.088
$0.29 \times 0.60 =$	0.174
Sum =	0.[illegible]86 volt.

The sum of these two voltages is

$V^c =$	0.048 volt
$V^d =$	0.[illegible]86 "
$V =$	0.[illegible]38 "

The conclusion is, that as long as the surface of the matte is clean, and no resistance offered by the non-conducting sulphur slime, that the bath will really require no outside current to run it but will practically run itself. The resistance of connections would absorb the small excess of voltage produced. This is as far as calculation can go. Practical experience with the bath records that the voltage required quickly rose to 1 volt, and after a few days running reached 5 volts. It is practically certain that this was caused entirely by the non conducting film formed on the anodes.

(2) With 588 amps. passing and 40 per cent dissolving copper, or 235 amps., the copper dissolved per day in one tank is

$$28.46 \times 235 = 6.688 \text{ grams}$$
$$= 6.688 \text{ kilograms}$$

and the weight of matte dissolved per day

$$0.688 \div 0.30 = 22.3 \text{ kilograms}$$

Since the 125 anodes in a tank weigh $20 \times 125 = 2500$ kilograms, their loss of weight per day is

$$22.3 \div 2500 = 0.009 = \mathbf{0.9} \text{ per cent} \qquad (2)$$

and to lose their whole weight would theoretically require

$$100 \div 0.9 = 111 \text{ days.}$$

Practically, the plates went to pieces in about half that time, when about one-half of their weight had been dissolved.

(3) The iron dissolved is 40 per cent of the matte decomposed, or 8.9 kilograms per day. This forms

$$8.9 \times \frac{152}{56} = 24.2 \text{ kg. } FeSO^4.$$

The tank is not quite full of solution, but say to within 3 cm. of the top. This gives a space of

$$200 \times 90 \times 97 = 1{,}746{,}000 \text{ c.c.}$$
$$= 1.746 \text{ cm.}$$

From this would be deducted the volume of the electrodes:

$$80 \times 80 \times 3 \times 20 = 384{,}000 \text{ c.c}$$
$$70 \times 70 \times 0.3 \times 21 = 34{,}300 \text{ "}$$

$$\text{Sum} = 418{,}300 \text{ "}$$
$$= 0.418 \text{ cm.}$$
$$\text{Volume of solution} = 1.328 \text{ "}$$

Assuming its specific gravity as 1.2, the weight of solution in a tank is

$$1.328 \times 1.2 = 1594 \text{ kilograms}$$

and its content of $FeSO^4$ is increased per day

$$24.2 \div 1594 = 0.015 = \mathbf{1.5} \text{ per cent.} \qquad (3)$$

The total salts present in the electrolyte, however, do not increase quite that fast, for since 16.73 kg. of copper are deposited per day and only 6.67 kg. are dissolved, the electrolyte loses copper at the rate of 10.06 kg. per day, equal to 25.24 kg. of $CuSO^4$ per day, which is 1.6 per cent of the weight of the electrolyte. We may, therefore, say that the electrolyte would lose 1.6 per cent of its weight of $CuSO^4$ per day and gain 1.5 per cent of $FeSO^4$—amounting to a virtual displacement of $CuSO^4$ by $FeSO^4$ until the copper was all removed. This would result in not many days running before the electrolyte would have to be replaced.

(4) We have previously calculated, for one tank, that 16.73 kg. of copper is deposited per day. This amounts for the whole plant to

$$16.73 \times 120 = \mathbf{2008} \text{ kilograms} \qquad (4)$$

Of this amount, however, only $6.67 \times 120 = 800$ kg. came from the matte, and the rest from the solution. Ample means must therefore be provided to supply fresh $CuSO^4$ solution, which was obtained by Marchesi from the roasting and leaching of ore.

(5) Precipitated copper has a density of 8.9. One amp. precipitates per day 28.46 grams. One amp. per square centimeter would therefore deposit in a day

$$\frac{28.46}{8.9} = 3.2 \text{ cubic cm.}$$
$$= 3.2 \text{ cm. thickness.}$$

But the current density used for depositing by Marchesi was only 30 amperes per square meter, = 0.003 amperes per square centimeter, which would deposit a layer per day of

$$3.2 \times 0.003 = 0.0096 \text{ cm.}$$
$$= 0.096 \text{ mm.}$$

To deposit a layer 1 cm. thick would therefore require

$$1.0 \div 0.0096 = \mathbf{104} + \text{ days.} \qquad (5)$$

This is a much slower rate of deposition than is used at present in copper refining where 100 to 500 amperes per square meter (9 to 45 amps. per square foot) are used. Low-current density deposits purer copper and absorbs less power, but gives a smaller output for a given installation, with consequent higher interest charges, labor costs, amortisation and general expenses.

I. 3—Electrolytic Extraction from Solutions.

This branch of the subject covers some promising processes, which have not, however, been as yet practically successful. Their consideration, however, from a quantitative point of view, is not devoid of interest or lacking in instruction.

The waters of many copper mines carry copper sulphate, produced from the weathering and leaching of copper sulphide ores. The solutions are generally too dilute to allow of concentration and crystallizing out to blue vitriol. The standard method of treatment is to pass the solutions over pig iron or scrap iron, thus precipitating the copper as a sort of metallic mud, called "cement copper," which contains much iron, besides the impurities of the iron used, so that it is sometimes only 90 per cent down to 60 per cent copper. This precipitate needs a strong refining to bring it up to merchant copper, with considerable loss of copper in the operation.

Two electrolytic methods are applicable to the treatment of such solutions: 1. The use of soluble iron anodes. 2. The use of insoluble anodes.

1. *Use of Soluble Iron Anodes.*

If iron in plates or sheets or bundles of scrap iron in a crate or holder is immersed in copper sulphate solution and simultaneously connected electrically with a copper plate to serve as cathode, no copper precipitates on the iron, but all is precipitated on the copper. The iron acts as a soluble anode, going into solution as ferrous sulphate, while the copper is deposited out massive, dense, and practically chemically pure, on the cathode sheet. Since more energy is developed by the solution of the iron than is absorbed in the deposition of the copper, there is electromotive force generated by the chemical action, which will run the tank like a short-circuited battery cell, if the iron and copper are simply connected by a low-resistance wire. This electromotive force will send a current of a certain amount through the cell, depending on its internal ohmic resistance plus the resistance of the external conductor. If it is desired to force matters, and to precipitate the copper faster than this anto-precipitation, an impressed electromotive force from a dynamo may be put on, and the cell made to work faster.

Problem 113.

A copper sulphate solution whose resistivity is 50 ohms is run for precipitation through tanks, each of which contains fifteen anodes of cast iron 40 x 80 c. m in size, and sixteen sheets of copper of similar size, the distance between averaging 5 c. m. The anodes and cathodes are short-circuited by resting on a triangular copper distributing bar of negligible resistance. Assume resistance of contacts to be such that 0.1 volt will be lost at them.

Required:

(1) The electromotive force generated by the chemical action.

(2) The total current operative in each tank, and the current density.

(3) The weight of copper deposited in each tank per day.

(4) The weight of iron dissolved in each tank per day.

Solution:

(1) From the thermochemical tables (Metallurgical Calculations, Part I. p. 24) we have:

$$(Fe, S, O^4, aq.) = 234{,}900 \text{ Calories}$$
$$(Cu, S, O^4, aq.) = 197{,}500 \text{ "}$$

$$\text{Excess of anode energy} = 37{,}400 \text{ "}$$

Since this is generated for each atom of copper deposited

and of iron dissolved, the excess energy per chemical equivalent concerned is 37,400 ÷ 2 = 18,700 Calories, and the total electromotive force developed is

$$18{,}700 \div 23{,}040 = 0.81 \text{ volt} \quad (1)$$

(2) The loss of voltage at the contacts being 0.1 volt, there is 0.71 volt operative to overcome the ohmic resistance of the solution. From the data given, the fifteen anodes operating on both sides, sandwiched between sixteen cathodes, give

$$15 \times 2 \times 40 \times 80 = 96{,}000 \text{ sq. cm}$$

active electrode surface, and taking this as the cross-section of the electrolyte between, we have its resistance as

$$50 \div 96{,}000 \times 5 = 0.0026 \text{ ohm}$$

the total current passing in the tank

$$0.71 \div 0.0026 = 273 \text{ amperes} \quad (2)$$

and the current density

$$273 \div 9.6 = 28.4 \text{ amperes per square meter} \quad (2)$$
$$= 2.6 \text{ amperes per square foot}$$

(3) Copper deposited in the tank per day:

$$28.46 \times 273 = 7770 \text{ grams}$$
$$= 7.77 \text{ kilograms}$$
$$= 17.13 \text{ pounds.} \quad (3)$$

(4) The iron going into solution will be to the copper dissolved as 56:63.6. If the iron is cast iron, this may be only 90 to 93 per cent of the loss of weight of the anodes, because they contain only that percentage of iron. If wrought iron or steel sheets were used, the iron dissolved would represent 99 to 99.8 per cent of the loss of weight of the anodes. The iron dissolved per day is

$$7.77 \times 56 \div 63.6 = 6.84 \text{ kilograms} \quad (4)$$
$$= 15.08 \text{ pounds.}$$

Problem 114.

One hundred tanks of the kind described in Problem 113 are arranged in a series, the anodes in each tank, however, connected as one large anode, and the cathodes in each as one large cathode. A dynamo is connected to the series capable of maintaining 110 volts across its terminals. The bus-bars provided are altogether 280 meters long, and are 1 x 4 c. m. in cross-section, of pure copper. All other details of the tanks are as before: resistance of contacts being 0.1 volt ÷ 273 amps. = 0.0004 ohm.

Required:

(1) The ohmic resistance of the bus-bars.

(2) The current operative in the circuit and the current density.

(3) The weight of copper deposited in each tank per day.

Solution:

(1) The conductivity of copper, in reciprocal ohms, is 600,000; its resistivity 1 ÷ 600,000 = 0.00000167 ohms. This is its resistance per centimeter cube. The resistance of the bus-bars is therefore

$$0.00000167 \times 28000 \div 4 = 0.0117 \text{ ohm} \quad (1)$$

(2) The total voltage operative in the circuit is the self-generated voltage of 100 tanks, plus the 110 volts from the dynamo, or

$$(0.81 \times 100) + 110 = 191 \text{ volts.}$$

The total resistance of the circuit is that of the 100 tanks, plus 100 sets of connections, plus that of the bus-bars

$$(0.0026 \times 100) + (0.0004 \times 100) + 0.0117 = 0.3117 \text{ ohms.}$$

The total current flowing will therefore be

$$191 \div 0.3117 = 618 \text{ amperes} \quad (2)$$

and the current density

$$618 \div 9.6 = 64.4 \text{ amperes per square meter} \quad (2)$$
$$= 5.9 \text{ amperes per square foot}$$

(3) $28.46 \times 618 \div 1000 = 17.59$ kilograms per day (3)
$= 38.79$ pounds per day

2. Use of Insoluble Anodes.

If insoluble anodes are used, the copper may be extracted *en masse* from such solutions, and its acid left behind. In such operations, the choice of an anode is not easy. Graphitized carbon plates are unattacked, and have practically no back electromotive force; high-silicon iron plates are also said to be very resistant, and pure silicon itself resists still better, but introduces considerable ohmic resistance. Sheet lead anodes become coated with a brown coating of PbO^2, which is permanent and evolves oxygen freely. Many other substances may possibly be used as anodes; not many practical results of such tests have been published. When operating thus, the electrolyte offers practically the same ohmic resistance as before, averaging probably a little less, and the chemical reaction absorbs energy. The resulting acidified solution may be utilized for dissolving easily-attacked copper compounds from fresh quantities of raw or roasted ore.

Problem 115.

An electrolytic depositing plant treats dilute copper sulphate solution containing 318 grams of copper per cubic meter as $CuSO^4$, and its copper is deposited by passing through tanks having insoluble anodes, electrodes 3 centimeters apart, and current density of 20 amps. per square meter. With good circulation, copper is precipitated with no evolution of hydrogen until the precipitation is practically complete. By having many tanks in series the current passing is kept very nearly constant at 300 amps. Each tank contains 1.5 c. m. of electrolyte.

Required:

(1) The voltage absorbed in the chemical reaction when precipitating copper and when the copper is all precipitated.

(2) The voltage absorbed in overcoming the ohmic resistance of the electrolyte at starting and at the end of the precipitation.

(3) The total voltage across the electrodes of a tank, at the beginning of the precipitation, just before the last of the copper is precipitated and after all copper is precipitated.

(4) The time required to precipitate the copper from a batch of solution.

(5) The output of copper per average kilowatt-hour of electric energy used, adding 0.2 volts to the potential across the electrodes for loss in contacts and bus-bars per tank.

Solution:

(1) When precipitating copper, we destroy $CuSO^4aq.$ and form the corresponding $H^2SO^4aq.$ Their heats of formation being

$$(Cu, S, O^4, aq.) = 197{,}500 \text{ Calories}$$
$$(H^2, S, O^4, aq.) = 210{,}200$$

and since the reaction is

$$CuSO^4aq. + H^2O = H^2SO^4aq. + O + Cu$$

we have to supply

$$(Cu, S, O^4, aq.) = 197{,}500 \text{ Calories}$$
$$(H^2, O) = 69{,}000 \text{ "}$$
$$\text{Total} = 208{,}500 \text{ "}$$

and get back $(H^2, S, O^4, aq.) = 210{,}200$ "

therefore supplying net = 58,300 "

and voltage absorbed in decomposition

$$\frac{58{,}300 \times 2}{23{,}040} = 1.27 \text{ volts} \quad (1)$$

When the copper is all deposited, then only H^2 and O appear at the electrodes, so that the voltage absorbed in decomposition becomes

$$\frac{69{,}000 \times 2}{23{,}040} = 1.50 \text{ volts.} \quad (1)$$

(2) At starting, the solution contains

$$318 \times \frac{1.5 \times 6}{63.6} = 79.8 \text{ grams}$$

of $CuSO^4$ per cubic meter, and since the cubic meter weighs at 15° practically the same as water, 1 c. c. 0.001 kg., our solution is

$$\frac{7.98 \div 1000}{0.001} = 0.08 \text{ per cent } CuSO^4$$

and also equals $0.798 \div \frac{159.6}{2} = 0.01$ normal.

At the end of the electrolysis the 0.01 normal $CuSO^4$ solution becomes a 0.01 normal H^2SO^4 solution. The resistivities of both these solutions can be found at once from electrochemical tables (e. g., Kohlrausch, in Landolt-Bornstein-Meyerhoffer's Tabellen).

0.01 Normal $CuSO^4$ = 1 ÷ 0.000717 = 1395 ohms
0.01 Normal H^2SO^4 = 1 ÷ 0.00308 = 325 "

With a current density of 20 amps. per square meter (0.002 per square centimeter) and a working distance of 3 c. m., the corresponding voltages absorbed in overcoming these ohmic resistances will be

$$1395 \times 3 \times 0.002 = 8.37 \text{ volts}$$
$$325 \times 3 \times 0.002 = 1.95 \text{ "} \quad (2)$$

(3) The total voltage across the electrodes, assuming the solution to contain no free acid at starting, will be

at start, precipitating copper: 8.37 + 1.27 = **9.64** volts
at close, precipitating last copper: 1.95 + 1.27 = **3.22** "
at close, evolving hydrogen: 1.95 + 1.50 = **3.45** " (3)

(4) Copper present in a tank: 318 × 1.5 = 477 grams.
Time required, 300 amperes

$$477 \div (300 \times 0.0003295) = 4826 \text{ seconds}$$
$$= 1 \text{ hr. } 20.5 \text{ min.} \quad (4)$$

(4) The average voltage consumed in overcoming ohmic resistance will be considerably less than the mean of 8.37 and 1.95 = 5.16 volts, because when the electrolysis is only half completed, and the solution is 0.005 normal in each ingredient, its resistance will be 487 ohms, and not (1.395 + 325) ÷ 2 = 860 ohms, and the corresponding voltage 2.92. This is because sulphuric acid is a so much better conductor than $CuSO^4$, that as soon as acid forms the solution becomes much better conducting. If we calculate the resistances and corresponding voltages absorbed in several steps, we would get more accurate results. Without going into the detailed calculation we will take 3.52 as the average voltage, and we then have the average voltage required per tank:

Decomposition	1.27 volts
Resistance	3.52 "
Contacts	0.20 "
Sum	4.99 "

Kilowatts used per tank

$$\frac{4.99 \times 300}{1000} = 1.497 \text{ kw.}$$

Output per tank per hour

$$300 \times 1.186 = 355.8 \text{ grams.}$$

Output per kilowatt-hour

$$355.8 \div 1.497 = \mathbf{238} \text{ grams.} \quad (4)$$

This is, of course, a small output compared with that of a refining process, but it must be remembered that this is an *extraction* process and its cost is not properly comparable with simple refining but with that of the processes which it replaces, such as precipitation by iron, and with cheap power and expensive iron there may be localities where this method would be economical.

Siemens and Halske invented a combined wet-extraction and electrolytic process, consisting in leaching the roasted copper ore or matte with a solution of ferric sulphate acidulated with sulphuric acid, producing thus a solution of cupric and ferrous sulphates, and then electrolyzing this solution in a cell having an insoluble carbon anode and a diaphragm between the electrodes. The solution is run first through the series of cathode compartments, where its copper is extracted, and back through the anode compartments, where its ferrous sulphate is perduced to ferric sulphate, ready to be used again in leaching ore.

The chemical reactions in leaching ore are

$$Cu^2S + 2Fe^2(SO^4)^3aq. = 2CuSO^4aq. + 4FeSO^4aq. + S.$$
$$3CuO + Fe^2(SO^4)^3aq. = 3CuSO^4aq. + Fe^2O^3.$$
$$CuO + H^2SO^4aq. = CuSO^4aq. + H^2O.$$

In the electrical precipitation we have:

in the cathode compartments:	$CuSO^4$	$= Cu + SO^4$
in the anode compartments:	$2FeSO^4 + SO^4$	$= Fe^2(SO^4)^3$
altogether:	$2FeSO^4 + CuSO^4$	$= Cu + Fe^2(SO^4)^3$

Confining our calculations to the electrolysis, we have $CuSO^4$ destroyed and $2FeCO^4$ simultaneously perduced to $Fe^2(SO^4)^3$, which is then available for re-use in the leaching tanks. The chemical work involved is:

(Cu, S, O^4, aq.)	= 197,500	Calories absorbed
2(Fe, S, O^4, aq.)	= 469,800	" "
(Fe^2, S^3, O^4, ^{2}aq.)	= 650,500	" evolved
Sum =	16,800	" absorbed

$$\text{Voltage thus absorbed} = \frac{16,800 \div 2}{23,040} = 0.36 \text{ volt.}$$

In addition to this, the voltage necessary to overcome the ohmic resistance of the cell must be counted in.

Problem 116.

An electrolytic tank for working the Siemens-Halske method was of wood, lead lined, 220 c. m. long, 100 c. m. wide and 100 c. m. deep. Each cell contained fifteen anodes and sixteen cathodes, the latter 80 x 80 c. m. x 1 m. m. The anodes were of carbon rods arranged as a grid 45 c. m. x 100 c. m. x 1 c. m. thick. A porous partition 1 c. m. thick was used, the *equivalent* effective free area of which was 0.05. Resistivity of electrolyte in cathode compartment 5 ohms, in anode compartment 8 ohms, partition in middle. Current density 100 amperes per square meter.

Required:

(1) The distance between the diaphragm and each anode and cathode surface, and the resistance of the cell, taking into consideration the contraction of current path due to the diaphragm.

(2) The voltage necessary to run the tank.

Solution:

(1)
15 anodes × 1 = 15 cm.
16 cathodes × 0.1 = 1.6 " .
Sum = 16.6 "

Space, anode to cathode

$$\frac{220 - 16.6}{30} = 6.8 \text{ cm.}$$

Space, anode or cathode, to diaphragm

$$\frac{6.8 - 1}{2} = 2.9 \text{ cm.} \quad (1)$$

Assume the solution in the diaphragm to have mean resistivity of 6.5 ohms, the equivalent free area being 100 × 95 × 0.05 = 475 sq. c. m. (area of diaphragm a trifle less than cross-section of tank). Mean area of electrolyte:

cathode compartment	(6400 + 9500) ÷ 2 = 7950 sq. cm.
anode compartment	(4500 + 9500) ÷ 2 = 7000 " "

Resistance of

anode compartment	$8 \times 2.9 \cdot 70 \ldots$	$\ldots$ ohm
cathode compartment	$5 \times 2.9 \div 705$	$= 0.0018$ "
diaphragm	$6.5 \times 1 \div 475$	$= 0.0137$ "

0.0188 " (1)

Voltage absorbed, for 64 amperes (= 2.64 sq. m depositing surface)

$0.0188 \times 64 = 1.20$ volts

$V^d = 0.36$ "

$V = 1.56$ " (2)

Carl Hoepfner devised a process along similar lines to the above, but based on the use of the two chlorides of copper. A solution of $CuCl^2$ in brine is used to act upon the ores or roasted matte, dissolving the copper with the formation of CuCl.

$$2CuCl^2 + Cu^2S = 4CuCl + S.$$

The cuprous chloride stays in solution in the brine, and is electrolyzed in tanks containing diaphragms, half the solution going through the cathode compartments and half through the anode compartments. In the former, copper is precipitated; in the latter, the equivalent amount of chlorine converts the CuCl present into $CuCl^2$, which can be used over, mixed with the depleted cathode solution. The total reaction is

$$CuCl + CuCl = Cu + CuCl^2$$

and the energy involved

$2(Cu, Cl)$	$= 70,800$ absorbed
(Cu, Cl^2)	$= 62,500$ evolved
Sum =	$8,300$ absorbed
=	0.18 volt.

Coehn devised a cell for carrying on this process without a diaphragm. The cathode is only half as long as the carbon anode, and the $CuCl^2$ formed at the latter is so heavy that it sinks to the bottom and is drawn off therefrom, while fresh CuCl solution is quietly poured in above. Since the cathode does not touch the cupric solution, it is not redissolved thereby, and the two solutions are kept separate.

A great advantage of this process is that Cu is monovalent in CuCl, and therefore twice as much copper is deposited as from $CuSO_4$ by a given number of amperes.

Problem 117.

Coehn (Jahrbuch der Electrochemie, 1895, p. 155) describes his improved partitionless Hoepfner apparatus as containing a copper cathode 100 c. m. wide by 50 c. m. deep, at a distance of 12 c. m. from a carbon anode; solution, 10 per cent NaCl, plus varying amounts of CuCl and $CuCl^2$. Current density 20 amps. per square meter.

Required:

(1) The voltage required to run the cell.

(2) The weight of copper deposited therein per day.

(3) The weight of copper per kilowatt hour electric power used.

Solution:

(1) The resistivity of 10 per cent NaCl solution is 8.5 ohms.

$$R = \frac{8.5 \times 12}{5000} = \ldots = 0.0204 \text{ ohm}$$

V^c, for ohmic resistance $= 0.05 \times 12 = 0.60$ volt

V^d, for chemical reactions $= 0.18$ "

$V = \text{Sum} = 0.69$ " (1)

(2) $28.46 \times 2 \times 10 = 569$ grams per hour (2)

(3) $569 \div 24 \div (10 \times 0.69) \div 1000 = 3435$ grams (3)

[The rest of the electrometallurgy of ... omitted in our November issue.]

The Utilization of Peat for Power Purposes with the Recuperation of Byproducts.

The utilization of peat is one of those subjects in which a host of investors have interested themselves and much money, ingenuity and energy has been spent to lead this intricate problem towards a solution. One of the most active workers in this field for a long series of years has been Prof. A. Frank, of Charlottenburg-Berlin, the same German chemical engineer who distinguished himself many years ago by his active work in introducing potassium salts into agriculture and quite recently by inventing, together with Dr. Caro, the process of making calcium cyanamide from calcium carbide. Anything that this successful engineer has to say on the difficult problem of peat utilization should, therefore, find most careful attention, especially as the matter will most likely become of great importance in future in this country.

This article is based on five papers, kindly sent to us by Dr. Frank (see also his letter in our correspondence columns in this issue). It is very interesting to see how the methods of utilizing peat have been gradually worked out, until now finally the commercial stage appears to have been reached. The titles of the five papers are as follows:

Über Verwerthung der norddeutschen Moore, insbesondere für elektrische Kraftstationen. Lecture held by A. Frank on Oct. 4, 1897. (Berlin: L. Simion, 1897.)

Über Torfgasbetriebe für grosse elektrische Centralen. Report presented by A. Frank on Dec. 17, 1903, to the Central Moor Commission.

Die Bedeutung des Torfes für die Provinz Ostpreussen. Two lectures held on Nov. 16, 1906, by N. Caro on the peat bogs as sources of energy, and by W. Feldt on the peat bogs as sources of raw materials and the utilization of peat deposits for agriculture. (Danzig: Verband Ostdeutscher Industrieller, 1907.)

Über Gewinnung und Verwendung von Torf zu Heizzwecken und zur direkten Krafterzeugung. Lecture held by A. Frank on Feb. 13, 1907. (Berlin: Deutsche Tageszeitung, Druckerei und Verlag A. G., 1907.)

In the Northern climate peat deposits are formed wherever stagnant water can accumulate. Peat is an accumulation of decayed vegetable matter, its decomposition still going on. The decay of the vegetable matter (mosses, roots, etc.) is an effect of the water, and first takes place in presence of air while in later periods air has no longer access to the forming peat. That the formation of peat is still going on is shown in places by observing an actual growth of the peat deposits in the course of years.

Fuel Made from Peat.

The direct applications of peat for agricultural purposes, the methods of working peat areas so as to make them available for farming, the use of peat as litter are discussed in the paper of Dr. Feldt quoted above, and need not be referred to at this place.

To understand the possibility of using peat for industrial purposes it is necessary to consider its composition. This varies greatly with respect to the content of water, the content of ash, the content of nitrogen, etc., but the "peat substance" proper, that is, the pure organic substance of the peat, has a rather uniform composition, namely, 60 per cent carbon, 5 per cent hydrogen, 35 per cent oxygen.

The water and the ash of the peat are simply obnoxious. The content of nitrogen may be made use of for the production of useful nitrogen compounds. On the other hand the composition of the peat substance proper given above shows that it represents a storage of energy, since carbon as well as hydrogen when oxidized set free considerable quantities of heat. Peat deposits, therefore, represent enormous quantities of stored up energy.

The difficulties in recovering the energy stored in peat are

due to the composition of the peat and to its structure. Peat always contains large quantities of water. Although the water may be reduced by previous trenching of the area, yet the content of water in peat should be always assumed as 80 to 90 per cent. and it becomes necessary to further reduce it artificially. The use of mechanical pressure to remove the water has not been found satisfactory. On account of the porous spongy structure of the peat, there are formed quickly under pressure impervious layers on the outside of the pressed volume, so that further removal of water is prevented. The same difficulty is found when the water is removed by sucking off or by the recently proposed method of electric endosmosis (see ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, Vol. I., p. 252) In any case so much power is required that the method is not economical.

The best method is always to first dry the peat in air, as was done already 2,000 years ago as recorded by Pliny. It has been proposed to combine this method of drying in air with a subsequent artificial drying by heat, the product being called "darrtorf," or to dry peat to a water content of 50 or 60 per cent and then compress it, the product being called "trockenpresstorf." Dr. Caro, however, thinks that neither of these methods is necessary, since it is possible to get quite satisfactory results by natural drying in air alone.

If the natural peat is directly dried in air the process takes a long time and the product is porous, hygroscopic and brittle, containing about 20 to 25 per cent water and having a low specific gravity; *i. e.*, there is little fuel per unit of volume.

Better results are obtained by the use of peat milling or crushing machinery. If in such machines the fibers are torn apart and the peat is kneaded, compressed and mixed, a uniform product is obtained which dries more quickly than natural peat and has a much denser structure, so that a solid cohesive product of comparatively high specific weight and a content of 15 to 20 per cent of water is obtained. (See also our Vol. III., p 421.)

"Machine peat" prepared in this way represents quite a satisfactory fuel which may be used for all purposes of heating. One kilogram of such peat may evaporate 3.5 to 4.2 kg. of water. Wherever the use of such peat as fuel has failed a wrong construction of the furnace has been at fault. The dimensions must be quite large on account of the comparatively low heat value of peat, and air must be supplied in proper amounts in order to secure complete combustion and permit the escape of the water which is in the peat and which forms during the burning process, as will be seen below.

Nevertheless, peat is an inferior fuel, and the use of peat as fuel must always be restricted to certain localities where other fuels are expensive. There is no possibility of peat competing with coal, though the latter sells at a fair price.

Dry Distillation of Peat and Production of Peat Coke.

Since peat represents chemically an intermediate stage between wood and bituminous coal it was to be expected that dry distillation of peat would yield a satisfactory coke together with tar, ammoniacal liquor and acetic acid as by-products. When peat is subjected to dry distillation—that is, under absence of air—water is formed from oxygen and hydrogen in the peat itself. Further oxygen and carbon in the peat combine to carbon monoxide and carbon dioxide, and finally hydrocarbons are formed from carbon and hydrogen in the peat. These products are distilled off and the balance of the carbon which remains back forms the coke. The first experiments were made, as in the distillation of wood, with "meilers," but these were not satisfactory. Better results are obtained with coking the machine-peat in closed retorts heated from the outside. The coke thus produced is rather hard, and the gas has such a calorific value that all the heat necessary for the distillation is provided by the gas. Further acetic acid and ammoniacal liquor are obtained.

A system which treats peat in this way is that of Ziegler, which has proven satisfactory and profitable in a plant in Oldenburg, while a similar plant in Rjedkino in Russia has been unsuccessful. The success of such undertakings depends on many factors, and greatly on local conditions. The price of peat coke depends on its purity, that is, on the quantity of impurities in the raw peat. In his lecture, 1907, Dr. Frank exhibited some samples of Ziegler peat coke from the new Upper Bavarian Coke Works in Beuerberg, and stated that this coke was of very satisfactory quality and would be a good substitute for charcoal. Nevertheless, the Ziegler process requires a rather pure peat, very low in ash, as raw material, and the necessity of preparatory treatment in machines is a disadvantage.

Peat Gas Producers and Generation of Power.

The processes which we have considered so far relate to the application of peat as fuel, either in the form of peat fuel or peat-coke fuel. In any case, it is important to first dry and compress the peat for these purposes down to somewhat like 20 per cent of water. Further, if one wants to produce good peat coke, one is restricted to the use of peat low in ash as raw material. Such processes may be profitable at certain places under local conditions, but they do not represent the solution of the general peat problem.

Prof. Frank attempts this solution in another way. Instead of trying to subject peat to a treatment that would make it available for shipment to industrial centers, he says we must endeavor to bring industry and commerce into the peat-deposit districts. Peat areas should be considered just like waterfalls, as centers of stored-up energy. In his first paper (1897) Frank considered the erection of large generating stations in the peat districts with reciprocating engines, the peat being used as fuel under boilers. But even in those early days Frank considered that it might be possible to gasify the peat in gas producers and use the gas directly in gas engines. This idea was taken up more strongly in his second paper (1903), since the large gas engine operated by producer gas, blast-furnace gases and coke-oven gases had made its appearance in the meantime in the industry. In this paper he estimates that in a gas-engine plant it is possible to produce about twice the amount of power which can be produced from the same amount of peat in a steam-engine plant.

In this paper (1903) it is also mentioned that the generation of a suitable producer gas from lignite and peat has been proven practical, that lignite gas engines are operating at the Mansfeld Gewerkschaft, near Eisleben, and on the Sophien mine, near Meuselwitz, and that peat gas engines have been built by the Deutz Gas Engine Co., by Koerting Bros., by Julius Pintsch, by the Oberursel Machine Co., and others. The Deutz Gas Engine Co. reported that when using air-dried peat, containing 16.57 per cent water, 1-hp. hour requires 1.27 kilogram of peat, while according to a later statement the same company has succeeded in reducing the quantity of peat required for 1-hp. hour to 0.85 or 0.9 kg.

But what is still more important, it is by no means necessary in such processes to dry the peat to such an extent that it contains only somewhat like 20 per cent of water. It is quite possible to gasify peat containing 50 to 55 per cent of water. Moreover, in this process, it is possible to recover almost the total nitrogen contained in the peat in form of ammonia.

In the dry distillation of peat only a small amount of the nitrogen is changed in ammonia, as is proven by the fact that peat coke thus produced contains considerable amounts of nitrogen; as an example the following analysis of peat-coke is given by Caro: 86.41 per cent C, 1.57 H, 1.26 N, 7.09 O, 3.67 ash.

On the basis of the well-known Mond process, Dr. Caro has worked out a new method for gasifying peat in a mixture of air and overheated steam in excess. This process has been tried with Irish peat on the Mond works in Stockton, and it

has been found that almost the total amount of nitrogen in the peat is changed into ammonium sulphate, which can be easily sold as fertilizer.

At the Stockton works the output from 100-kilogram peat, calculated as free from water and containing somewhat more than 1 per cent nitrogen, was 2.8 kilograms ammonium sulphate and 250 cubic meters of producer gas with a calorific value of 1,300 calories.

Dr. Caro gives the following results obtained in tests in Winnington, England, where there is a large Mond gas producer plant. The Mond gas producers which were available there were partly used for gasifying peat. The peat gas was supplied to the gas engines which were otherwise operated with Mond gas, and ammonium sulphate was recovered in the same works.

The engineer in charge of the gas engine plant did not know whether he received Mond gas or peat gas, because all gas came through the same supply mains. He did not even find the difference in the operation of the gas engines.

Italian peat was employed in these tests since they were made in the interest of a projected works in Italy.

"Six hundred and fifty tons of peat were gasified in the whole. The composition of the peat substance, assumed free from water, was ash 15.2 per cent, volatile substances 43.8 per cent, nitrogen 1.62, total carbon 56.3, fixed carbon 34.2, with a calorific value of 5,620 large calories. The peat was used in different conditions, mostly with an average content of 40 per cent water, and 1,780 cubic meters of gas with a calorific value of 1,360 large calories were obtained per ton of water-free peat substance. Besides this there were obtained 118 British pounds = 55 kilograms ammonium sulphate per ton of water-free peat. I state again that this was not ammonia gas, but real salt which was weighed.

"The gas was partly used for generating the steam required for the gas producer process, partly for heating the ammonium sulphate solution, and besides this an excess of gas was obtained, namely for each ton of water-free peat gas was obtained giving 480-hp. hours in gas engines.

"In this plant the cost of the treatment of 100 tons of peat (the weight being calculated on the basis of water-free peat) was $50, including wages ($1 to $1.25 per man per day), repairs, etc. Further, for the production of the ammonium sulphate, sulphuric acid, costing $41.25 (at $7.50 per ton), was used. Finally, if the amortization is taken as $33.75 (at 10 per cent), the total cost is $125. On the other hand from these 100 tons of water-free peat ammonium sulphate in the amount of about $325 was obtained. This shows a good profit, especially if it is considered that the gas is supplied to the gas engines in absolutely pure condition.

"It has been found that the segregation of dust particles in a gas which has been freed from ammonia, takes place with much greater speed and intensity than in peat gas containing tar. One cubic meter of gas contained only 0.16 gram of tar, and the gas engines operated with this gas very well and without trouble. The content of hydrogen in the gas does not vary more than ½ per cent in the maximum.

"The cost of the 480-hp. hours produced was, of course, very low. If we do not take into account the profit from the ammonium sulphate the cost of the electric horsepower hour was less than 0.125 per cent."

Finally, peat gas produced in this way is not only suitable for generation of power, but may be used for all kinds of heating purposes if proper furnaces are employed. Its use in steel works recommends itself, since it is absolutely free from sulphur.

In order to test the process in the interest of German industry, an experimental plant is being erected on the Mont Cenis mine in Sodingen, in Westphalia, as was already mentioned in our April issue, page 145, for the treatment of waste coal and peat. If successful, the chief result will be the use of wet non-briquetted peat in gas producers for the generation of cheap power and the production of ammonium sulphate. The income from the latter alone is expected to assure a fair interest on the capital; $187,500 is given as the capital invested in this plant. The results of these tests will certainly be awaited with interest.

Production of Phosphorus in the Electric Furnace.

In a recent publication of the United States Geological Survey, entitled "The Production of Phosphate Rock and Phosphorus in 1906," Mr. George W. Stose gives an interesting summary on the development of the manufacture of phosphorus and of the rôle which the electric furnace has played in this development.

Phosphorus was formerly produced from bones and other organic substances, and it is only recently that it has been extracted from mineral deposits. The mineral from which phosphorus was first obtained was rock phosphate, an impure fluophosphate of calcium, from which soluble phosphate fertilizer is generally made. Apatite, a fluophosphate, or chlorophosphate of calcium, has been used in Europe and Canada to a small extent. Quite recently wavellite (aluminium phosphate) has become a source of phosphorus, a sufficiently large supply of this deposit being available at Mt. Holly Springs, Pa.

The old method of making phosphorus that has been in use since the beginning of the nineteenth century is as follows: Bones are roasted and crushed, and the powdered bone ash (calcium phosphate) is treated with sufficient sulphuric acid to convert all or part of the calcium into calcium sulphate and the phosphorus into calcium metaphosphate, or even into phosphoric acid. This is partially evaporated, mixed with powdered charcoal, and reduced in a furnace in a clay retort. Phosphorus vapor and carbon monoxide distill off, and the phosphorus is condensed under water in a yellow waxy form.

Theoretically, the reaction would be:

$$2Ca_3(PO_4)_2 + 6H_2SO_4 + 12C = 6CaSO_4 + 12CO + 2H_2 + P_4 + 4H_2O.$$

It is found in practice, however, that the following equation represents more nearly what takes place:

$$3Ca_3(PO_4)_2 + 6H_2SO_4 + 10C = 6CaSO_4 + Ca_3(PO_4)_2 + 10CO + 6H_2O + P_4.$$

In this process much loss is occasioned by the destruction of the retorts by the acid and the intense heat, and only about one-half of the phosphorus in the charge is recovered. There is also danger of igniting the phosphorus when removing it, and great delicacy is required to prevent the vapor from condensing in the tubes and clogging them. Many improvements and modifications of this process have been patented in recent years. Woehler early suggested that calcium phosphate, either burnt bones or rock phosphate, be heated with sand and carbon without the sulphuric acid treatment, and the Wing patent, 1891, followed the same general method.

Wing Process.—In the Wing process the charge of bone ash, or pulverized rock phosphate, and silica is moistened and made into balls and is placed in layers in the cupola with coal between, which furnish incandescent carbon to reduce the phosphoric acid fumes. The silica releases the phosphoric acid from the phosphate in the form of anhydride P_2O_5, which is reduced by the incandescent carbon and a reducing flame to phosphorus. The fumes pass off to depositing chambers kept at a temperature of 500° F., where most of the phosphorus is deposited in the red form and the remainder is caught in a water chamber as yellow phosphorus. The process is made continuous by feeding the charge from the top, dumping the residuum from the grate below, and using two depositing chambers alternately. With only the ordinary furnace at command this method was found impracticable on account of the high

a great heat required to smelt so refractory a charge. Electricity as a powerful heating agent had been known for some time, and was looked to as the solution of the problem, but the invention of the electric furnace has only recently made it commercially feasible. It has now been generally introduced throughout Europe and America in the production of phosphorus on a profitable basis.

Readman Patent.—This is the process which, since its introduction in 1889, has come into commercial use in most countries. Bone ash or crude phosphoric acid is mixed with powdered coal or charcoal or, if mineral calcium phosphate is used, it is roasted, crushed and mixed with charcoal and silica or some basic salt. The mixture is reduced in a continuously operated electric furnace in a reducing atmosphere, by passing the current from carbon electrodes through the mass, which acts as a resistant conductor and is heated to incandescence. The silica combines with the calcium to form calcium silicate slag. The phosphorus and carbon monoxide distill off as before. Distillation begins at 1,150° C., and requires 1,400° to 1,500° C. to complete the process. The chemical reaction is $2Ca_3(PO_4)_2 + 6SiO_2 + 10C = 6CaSiO_3 + 10CO + P_4$.

Harding Process.—In Harding's patent, 1898, pulverized rock phosphate is boiled with sulphuric acid, and the phosphoric acid, free from lime, is filtered out and boiled down to a sirup. This is mixed with granulated carbon, heated in a reverberatory furnace, and then smelted in an electric furnace by electric arcs between the electrodes and the mass. A hydrogen atmosphere is obtained by spraying gasoline into the furnace.

Gibbs Furnace.—In this furnace, which was devised especially for phosphorus manufacture, the electricity instead of discharging through the mass passes through a continuous high resistant medium, such as a carbon rod, placed above the charge. The rod becomes incandescent and the roof, which is arched over the grate, reflects the heat as in a reverberatory furnace.

Irvine Furnace.—The Readman process was modified by the Irvine patent in 1901. The charge is the same as in the earlier method, although either aluminium or calcium phosphate can be used with the silica or basic salt flux. The two carbon electrodes are suspended vertically from above and are connected below at the start by coal, through which the current passes. After the charge melts the slag forms on top, and thereafter the current passes through it as the conductor between the electrodes. Fusion is continuous, and the excess of slag is tapped off gradually so as not to expose the ends of the electrodes.

Duncan Patent.—A process patented in 1903 by Duncan takes 77 parts of powdered phosphate, either organic or mineral, and 23 parts of powdered carbon, mixed with tar as a binder. This is dried, and after a preliminary heating as a matter of economy in a hydrogen flame, a by-product in the manufacture, it is placed in an electric furnace and calcium phosphide continuously produced. This is put into a chamber submerged in hydrogen; after adding water it forms phosphorus hydrides. Upon heating the hydrides are reduced to phosphorus in pure state, either red or yellow, depending upon the degree of heat at which it is allowed to deposit.

Parker Patent.—In 1902 Parker patented a process in England for the reduction of aluminium phosphate. It is treated with sulphuric acid and then with an alum-forming sulphate, all the alumina being removed by the crystallization of the alum previous to the electric treatment. The residual liquor is mixed with coal and other carbonaceous material and reduced in an electric furnace.

Landis Method.—The American Phosphorus Co., of Philadelphia, have a plant at Yorkhaven, Pa., where they extract phosphorus from wavellite by a method invented by Mr. G. C. Landis, chemist of the company. The process, which is kept a secret is, so far as could be learned, similar to the Readman method, except for the ore and the furnace. Wavellite, aluminium phosphate and calcium phosphate, obtained from South Carolina, are roasted, mixed with silica and charcoal, and reduced in the patent electric furnace. In January, 1907, a patent was secured on certain improvements in the furnace designed to prevent the escape of fumes, vapors and gases, or their absorption by the furnace lining. This is accomplished by an outer lining of non-absorbent brick and by a sealing device for all openings into the furnace whereby the projecting flanges of the joints are inclosed in a moat of water. The furnace has an inner lining of carbon bricks which acts as one electrode and one or more vertical carbon electrodes are used which may be adjusted either to furnish a continuous current through the charge or to produce with it an electric arc. The slag is drawn off every 3 or 4 hours and the phosphorus fumes condensed under water. Probably some additional treatment is required to remove the alumina in the batch similar to the Parker patent, and this is what is kept secret. (For details of construction of the Landis furnace and a diagram of the same see page 55 of our February issue. See also page 378 of our September issue.)

The phosphorus obtained by most commercial processes is a crude form of white or yellowish waxy variety, and contains sand, carbon, clay and other impurities. These are removed in various ways—by filtering while molten through powdered charcoal or canvas submerged in water, by forcing the molten mass through porous pottery by means of steam, and by redistillation in iron retorts. The best method of purification, however, is to treat the crude phosphorus, when molten, with a mixture of potassium dichromate and sulphuric acid, or sodium hypobromite, some of the impurities being dissolved, others rising to the surface as scum.

Because ordinary white phosphorus is very poisonous and injurious to handle, other forms of the element have been sought. Red amorphous phosphorus, which is not poisonous, is readily prepared by heating the ordinary variety to 250° C. in a closed vessel under pressure or excluded from air and water. It has not the same qualities, however, as the white crystalline variety. A red crystalline form, recently discovered in Germany, is made by heating to boiling a 10 per cent solution of white phosphorus in phosphorus tribromide. This is not poisonous and is an efficient substitute for white phosphorus in making matches.

The industry in this country is so young that statistics are difficult to obtain; in fact, general information on the subject is lacking. The world's production of phosphorus has been variously estimated to be from 1,000 to 3,000 tons a year, and until very recently this was almost entirely a foreign industry. The greater part of the world's supply is made in the Albright & Wilson factory, Wednesfield (Oldbury), England, where the Readman process originated. The output is said to be 500 tons a year. Other large factories are located at Lyon, France, and at Griesheim and Frankfort, Germany. There is also a plant in Sweden, and numerous smaller ones in Russia, six of which, located near Perm, had an output of about 140 tons in 1890.

In the United States the first phosphorus works were built about forty years ago in Philadelphia by Mr. Moro Phillips, and this factory has continued in operation until very recently. The J. J. Allen's Son's plant was established in Philadelphia in 1891, and it supplied the Diamond Match Co., the largest match factory in the United States, in competition with imported phosphorus. In 1897 the English firm of Albright & Wilson, under the firm name of the Oldbury Electro-Chemical Co., built a 300-hp. factory of the Readman type at Niagara Falls, which thereafter supplied the Diamond Match Co. and the greater part of the domestic product. This firm has recently made a further improvement in its plant by introducing the Irvine patent furnace, by which method 80 or 90 per cent of the phosphorus is reported to be extracted from the raw

material, a high-grade phosphate rock. This is similar to the results obtained in the English works, where 80 per cent is recovered. They have six furnaces of 50 hp. each with a capacity of 170 pounds of phosphorus a day, a total of 1,000 pounds a day. Their production varies according to the demand, but they furnish at present over 50 per cent of the domestic product.

The General Chemical Co. recently acquired the Duncan patent. Another company was established at Long Island, where it operated furnaces by electricity from city supply.

The American Phosphorus Co. built its first plant in 1902, at Moores Mill, near Mt. Holly Springs, Pa., where its wavellite mine is located. The old method of heating by gas was employed. This mill burned down, and another was built and put in operation by 1905. Electric furnaces were installed in the new plant and operated during 1905; but the production of electricity by steam was too expensive, and in 1906 the mill was moved to Yorkhaven, Pa., where electricity generated by water power could be had. This company reports a production of about 500 pounds a day and a capacity of about 1,200 pounds.

At the census of 1900, three establishments were reported in operation, but at the 1904-5 census only the Oldbury Electro-Chemical Co., of Niagara Falls, reported.

In addition to the domestic production, the United States imports annually from 30,000 to 40,000 pounds of phosphorus, on which a duty of 18 cents a pound is paid. The price in the New York market ranges, according to quality, from 45 to 70 cents a pound.

The same pamphlet contains a paper by Myron L. Fuller on the production of phosphate rock. The production in the United States has increased from 1,947,100 long tons ($6,763,403) in 1905 to 2,080,957 long tons ($8,579,437) in 1906. Phosphate rock is used altogether in the manufacture of artificial fertilizers and chemicals containing phosphoric acid.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our London Correspondent.)

The British Association Meetings at Leicester.

While the ordinary fortnightly or monthly meetings of the various scientific societies have an intermission of from four to six months during the summer, the actual activity of paper reading and discussion bursts out here and there during the nominally holiday months. This activity began this year with the Iron and Steel Institute meetings, then came the triennial engineering conference of the Institution of Civil Engineers, with its multifarious subject matter. Then followed the Dundee meeting of the Institution of Mechanical Engineers and the British Association meeting at Leicester. In September there will be the Iron and Steel Institute Autumn meeting in Vienna. Technical "copy" therefore has been unusually plentiful.

Of course, the British Association papers dealt with a large number of different subjects. Prof. Silvanus Thompson's presidential address to the Engineering Section was partly an historical review and partly a philosophic discussion of the education and training of the engineer. The papers dealt with questions in abstract physics such as the "Constitution of the Atom," the "Density of the Ether," etc., laboratory phenomena, such as radio-activity, and matters more closely related to dividends, such as a paper on gas and petrol engines, or on metallic filament lamps, or on rail corrugation, or on the effect of ice in Canadian hydroelectric installations.

Rail Corrugation.

Of directly metallurgical interest was Mr. Worby Beaumont's paper on "The Origin and Production of Corrugation of Tramway Rails." The following are the author's conclusions:

1. The compression of the material of the table of the rail by the tramcar wheels; cold rolling. 2. The microscopic deformation of the surface of the rail on the small area of contact between wheel and rail, that deformation being attended by a depression under the wheel. 3. That the material of the surface in front of the wheel and the depression recurrently form a slight ridge of unassignable height, over which the wheel mounts. 4. That the area of contact between wheel and ridge is minute, and the pressure, therefore, very great per unit of area, and hence the severe pressing of the ridge into the material of the rail table and its hardening or its crushing. 5. That the distance between each ridge thus formed by the rolling wheel will vary slightly with the strength, hardness and toughness of the rail, and with the speed of the car wheels. 6. That the originating ridge forming the incipent hard patch is added to, on the formative or rear side, thus gradually extending from a more transverse line to an area of increasing length. 7. That the hard patch thus formed for a time resists the destructive deformation by the wheel, but that it increases the rate of local side detrusion, and that the extruded material is in some positions of the rail worn off by the flanges of the wheels, which are thereby pushed laterally against the other side of the rail groove, and make more or less distinctive marks therein. 8. That a steel rail loses a large part, if not most, of its weight in wear by the separation of the compressed and crushed surface by minute exfoliation, the surface film exceeding the dimensions of the sub-surface, and separating itself by disintegration, flaking or crumbling, as shown by pitting. 9. That this disintegration of the surface partially relieves the surface film of the destructively compressed parts and the sub-surface of the corresponding tension. 10. That the hard, bright patches depend for their duration upon the strength of their supporting materials, and in many cases should disappear, though they reappear in different position. 11. That the appearance of the hard patches on the outer curves of some lines where none appear on other of the rails of the same line is due to the heeling over of the cars on the curve and the extra weight thereby put on the outer wheels on this outer curve. 12. That it is possible that the final passes of some rails through the rolls at a comparatively low temperature may produce a condition in the rail conducive of imitation of corrugation, and thus accessory before the rail is laid. 13. That there are numerous circumstances and conditions in the working life of a tramway rail which produce great contrariety in results, including (a) its correct laying, which causes a greater or lesser width of the table to present itself to the wheel thread; (b) the grinding slip of the propelling wheels on one side of the car affected by the condition of the rail surface and by the heavier load on the outer rails on curves, causing or permitting the wheels on the inner rails to slip; (c) the speed of the cars; (d) the character of the dirt and grit on the rails, the construction of the rail, etc. 14. The remedy appears to be (1) lighter cars; (2) harder rails; (3) moderate speeds and larger wheels.

Helium and Radio-Activity in Common Ores and Minerals.

The Hon. R. J. Strutt's paper on this subject pointed out that it had now been recognized that the origin of the presence of helium in many minerals was due to the radio-active changes, and the object of his recent investigations had been to see if helium can be found in certain common minerals which are not known to contain even traces of radio-activity. He had been able to find traces of helium in almost all metalliferous ores and strong minerals. Concurrently with the helium determination the quantity of radium was also determined by well

known methods, and it was found that the quantity of radium present is in almost all cases sufficient to explain the helium without postulating its production with the small radio-activity, which there has been reason to associate with common elements

Modern Machinery and its Future Development.

Mr. H. J. Brakenbury's paper was chiefly devoted to giving an account of the factors which have tended to make machine tools develop on certain lines, and to showing that there were forces now at work which might considerably alter our views and ideas as to the value of certain classes of machinery. In dealing with the efficiency of automatic turning machines compared with those worked by hand, he gave a number of curves of costs, taking into account wages, rate of output, cost of machine cost of tools and setting up, and cost of material. The conclusion was that automatic machines show a saving when the capital cost is not more than £250 each. After this figure a loss is shown, which increases very rapidly. He thought that the large automatic machine was a creation of the past, and that the future would bring no further development in this direction. The simple automatic machines of small size were of the greatest value. The complicated machines for work requiring many short operations were not economical.

Passing on to grinding machinery, Mr. Brakenbury spoke of the great improvements which had been made in the direction of increased speed of removing material, but said that he did not think that finality had been reached. He referred to a new feature which was being introduced in the form of an automatic sizing arrangement, which automatically changed the feed from roughing to finishing, and knocked out the feed when the finished side had been obtained quite independently of the wear of the wheel. Another tool to which he thought there was a great future was the screw milling machine.

The Measurement of the Forces on a Cutting Tool.

Mr. J. F. Brooks described "A Machine for Weighing the Forces on a Cutting Tool," the object of which is to measure the three co-ordinate components of the force on a cutting tool while in the act of cutting metals. The tool, fixed in a holder, forms part of a simple lever, carried by a thin diaphragm of steel. This device gives a universal frictionless pivot when used for very small displacements. The location of the lever is effected by means of electrical contacts in circuit with telephone receivers. Weights are used to balance the forces. The apparatus is capable of measuring maximum, minimum, as well as mean values. The position of the center of pressure may be found by two or more experiments. The paper was illustrated by diagrams, showing the value of the forces on tools with cutting angles of 65° and 70° when cutting cast iron and mild steel, with small cuts at moderate speeds.

The Prospects of the Aluminium Corporation, Ltd.

A recent statutory meeting of the shareholders of the Aluminium Corporation, Ltd., afforded the chairman, Sir James Sivewright, an admirable opportunity of outlining the contemplated activities of this undertaking. He pointed out that the company was formed according to the prospectus, which was to acquire certain freehold property and water rights of a place in North Wales for the development and production of aluminium. The original idea was to lease the premises, but after consideration the directors thought that it would be far more economical to obtain the freehold of the buildings, and they had paid the sum of £55,000 for the freehold rights. The extent of the premises was 1,300 acres, which included the area of Lake Eagure, which covered 86 acres. They also received a rental of £528 for land, and they had no doubt that that land would considerably increase in value in the future. The works at present were in active course of construction, and according to the terms these works were to be completed in twelve months, and the whole of the undertaking in two years. Desirous as they were of getting power as quickly as possible, they had made arrangements with the North Wales Electric Power Co. for the supply of 600 kw., at a price which they considered very satisfactory. After consideration the directors had increased that supply to 1,200 kw., or 1,600 hp., so that instead of having 6,000 hp. available as stated in the prospectus, they would have, when all the works were completed, nearly 7,000 hp. available. Having in their minds that it was the best thing to get the cheapest way of producing the metal, the company had made arrangements with the Newcastle Electric Supply Co. for a supply of current for power purposes at Tynemouth. They hoped to get from that some 4,000 kw. per annum at a price which they considered satisfactory. The directors had secured a plot of land almost adjoining the works of the electric company, and the construction of the buildings was now going on. If the North Eastern Railway Co. fell in with their idea as regarded price they hoped to have a railway siding built alongside of the works, which would be of great advantage. As to raw materials, they had entered into contracts which would come into effect as soon as they were capable of producing aluminium. He saw no reason why they should not be in a position to turn out the metal at the end of this year or early in 1908. They did not anticipate any drop in the somewhat high prices which now ruled for the metal. The demand was largely in excess of the supply, and the merits of the article were such that they had no doubt that their company would be a prosperous concern. The field for aluminium was so large that he thought the shareholders in that company had good prospects in the future.

An Electrically-Controlled Single Lever Testing Machine.

The Aberdeen meeting of the Institution of Mechanical Engineers had one paper only before them, which was metallurgical in its nature, namely, that by Mr. C. E. Larrard, on the above subject. The machine in question has been installed at the mechanical engineering department of the Northampton Institute.

The remarkable control obtained in this machine for torsion as well as the more usual tests of tension, compression and bending, is due to the use of two electric motors with wide-speed ranges, the high range in the rate of straining by hydraulic pressure, and the fact that the handle and other adjustments are controlled from one position. These and other special features, together with an efficient chronograph for indicating the time intervals during straining and loading, will, the author believes, enable fresh investigations on the strength and properties of material to be carried out.

The machine is one of Mr. Wicksteed's vertical single-lever machines, with a low-lever ratio, satisfying in every respect the requirements of the Board of Trade. A maximum stress of 150,000 pounds can be impressed on the specimen for tension, compression and bending, while torsion tests can be made on short specimens up to a moment of 400,000-inch pounds. The poise weight, which can be given two values, is under electrical control in either direction, or hand-driven when required. The straining for tension, compression and bending is, as usual with these large machines, effected by hydraulic pressure, while for torsion the twist is put on by means of an electric motor.

Market Prices During August.

In the chemical trade sulphate of ammonia is 2s. 6d. per ton firmer at £11.17.6. The coal tar products are unchanged. Copper sulphate has receded from £31 to £27 per ton in sympathy with the fall in the price of copper.

The soda products are unchanged.

As regards metal prices, the copper situation has been unchanged. The fall commencing at £96 per ton on July 24, which had reached £86.15 per ton on Aug. 1, continued until Aug. 13, when £76 was touched. Thereafter followed irregu-

larities, including a rally to £79 on the 21st, a fall to £77 on the 26th, with a final closing on Aug. 30 of £76.7.6 and a general reticence on the part of consumers to buy for immediate needs only. There are signs, however, of returning confidence and of a tendency to cover future requirements.

The movements of tin prices have been rather startling. Opening at £180 on Aug. 1, prices fell to £165 on Aug. 14, rallied to £169 on Aug. 16, fell to £166 on the 22d, rose to £170.10 on the 27th, and closed at £169.

Lead has been fairly firm, opening at £20.5 per ton and closing at £20, the highest price being £20.10 on Aug. 14.

Cleveland pig iron has been very steady, opening at 57s. 3d. per ton and closing at 56s. 4½d. Hematite has been well maintained, opening at 78s., touching 79s. on the 7th and 78s. on the 15th, and closing at 80s.

Antimony is fetching £38 per ton and platinum £5 per ounce. Steel rails and plates are firm at £7 12.6 and £6 15 respectively.

Stocks are low, and the present activity seems likely to be of continuance. Shipbuilding—save for orders for warships has perceptibly slackened, but foundries and rolling mills are full of work. The hardening of the price of fuel is somewhat disturbing.

London, Sept. 3, 1907.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS

Electric Furnace.

Regulating the Iron Reduction in an Electric Furnace.—P. L. T. Héroult, 861,280, July 30, 1907. Application filed April 25, 1906. Assigned to Société Electrometallurgique Française.

In smelting iron ore in a furnace with one vertical electrode, while the crucible below forms the other terminal, it is possible by adjusting the quantity of lime added to the charge to produce a thinner or thicker scale or lining upon the side walls of the furnace in the fusing zone. If more lime is added than is necessary to maintain the composition of the slag, the excess lime forms a scale or lining. On the other hand, to diminish the thickness of this scale, it is only necessary to supply less lime than the slag requires, whereupon the slag will dissolve the scale until its equilibrium is restored. By adjusting the thickness of this scale it is possible to diminish or enlarge the cross-section of the zone of fusion, thus concentrating more or less the energy density in the fusion zone. If the cross-section is reduced and the energy density increased, the electrode is lifted by the usual automatic mechanism which maintains the voltage and current constant. The increase in the length of the zone of fusion then increases the rate of reduction in this zone and produces a pig of higher silicon content. The reason given by Dr. Héroult is that when the electrode is raised the incandescent carbon column becomes longer, and this added resistance enables the arc (which extends from the lower end of the electrode to the top of the carbon column) to become a little shorter. Consequently there is less heat for the melting of the oxide of the charge, and the operation of the furnace is less rapid, but the oxides which are melted pass through a long column of carbon and are more completely reduced. Since it is at least approximately true that the iron is first reduced and then the silicon, it follows that the elongation of the zone of fusion produces an increased silicon content in the product. Therefore by increasing the thickness of the scale, the silicon content of the product is increased, or by decreasing the thickness of the scale, the opposite effect is obtained.

Steel Refining.—P. L. T. Héroult, 851,167, April 23, 1907. Application filed April 28, 1906. Assigned to Societe Electrometallurgique Francaise.

To refine a metal, Dr. Héroult prepares a bath of it and oxidizes it to such an extent as to transfer the impurities from it to the slag while maintaining its melting point below the temperature of the furnace, so that it remains liquid until the transfer of the impurities is substantially complete. The metal is then solidified, while the slag is maintained molten and the slag with the impurities is removed, after which the metal is remelted and treated as desired to obtain the final composition.

For the purification of steel either in an open-hearth furnace or in an electric furnace the following special notes are given: It is assumed that a basic open-hearth furnace of the tilting type is used. The fusing point of steel or iron varies with the composition, increasing with the purity of the metal. Crucible steel (containing, say, 1 per cent of carbon), for example fuses at approximately 1,400° C. As the carbon is reduced, we have soft steel of, say, 0.10 per cent carbon, which fuses at approximately 1,600° C. Substantially pure iron (deoxidized) fuses at approximately 1,900° C. If, however, the iron of substantial purity (containing, say, 0.01 per cent carbon, 0.01 per cent of phosphorus, and 0.015 per cent sulphur) be over oxidized, its fusing point is reduced. When it contains, roughly, about 0.75 per cent oxygen, its fusing point is lower than that of soft steel, both of these being well within the temperature attainable in a Siemens furnace. The present invention utilizes these variations in the fusing point, and it is assumed that the temperature of the furnace throughout the process is maintained above the fusing point of soft steel and below that of pure iron deoxidized. According to the present invention the oxidation of the bath is continued not only until the desired percentage of the carbon has been oxidized, but beyond this point until substantially pure iron superoxidized is obtained. In this superoxidation substantially the whole of the impurities are transferred to the slag. The pure metal is then deoxidized, so that its melting point is quickly raised above the temperature of the furnace. It solidifies as soon as it is sufficiently deoxidized, and we thus have in the furnace a solid base of deoxidized pure iron very smooth on its upper surface, and upon which there is a molten slag which can be readily removed, carrying with it the impurities which have been extracted from the iron. It is for the purpose of dumping the slag that a tilting furnace is advantageous. The surface of the iron is so smooth that the slag may be removed almost to the last drop. The impurities being withdrawn, the pure iron may be converted into steel of any desired composition. For example to make soft steel or crucible steel, both of which fuse at the temperature of the furnace, it is only necessary to add carburizing materials, such for example, as carburite (a mixture of carbon and iron) or pig iron of high purity. A neutral slag is also applied to the surface of the metal to protect it from the oxidizing action of the flame. The continuance of the process will be in accordance with the usual practice, and depend upon the product desired, which may, for example, be basic open-hearth steel of high purity.

The raw material may be ordinary scrap, which is melted down and oxidized by the flame and by the ore usually added. The bath may be fed with additional scrap or pig, only taking precautions not to deoxidize it. After the bath is well melted and superoxidized, the deoxidation may be effected by adding pig, the conditions being continued until the freezing occurs. Any neutral slag may be used for the last stage of the process, such, for example, as lime, sand and clay, or other materials which will be fusible and protect the metal from the flame. The slag is not expected to exert any chemical effect on the steel.

massive ... there is nothing to be removed therefrom. After the final ... ing of the steel it may receive the usual additions of manganese, silicon, aluminium, or the like, to ensure the casting of sound ingots as far as possible. By this process steel of very high purity may be obtained from very poor or impure stock.

Low Carbon Ferro-Alloys.—E. F. Price, 865,009, Sept. 10, 1907. Application filed Nov. 14, 1905.

The inventor produces low carbon ferro-chromium, ferro-manganese, ferro-titanium, ferro-vanadium, etc., by the use of ferro-silicon as reducing agent. In the first stage of the process, therefore, ferro-silicon, high in silicon and low in carbon, is produced, by electrically smelting a charge of silica, iron ore or iron and carbon. The molten silicide is tapped from the smelting furnace and allowed to solidify. The ingot is then broken into fragments which are mixed with a granular body of the compound to be reduced, for example, chromite, and the mixture is melted in an electric furnace, the charge serving as resistor, with the use of a basic flux, such as lime.

Vanadium, Ferro-Vanadium, Etc.—F. M. Becket, 866,561, 866,421 and 866,562, Sept. 17, 1907. Applications filed Dec. 22, 1900, Jan. 31, 1907, and June 12, 1907, respectively. Assigned to Electro Metallurgical Co.

Patent 866,561 refers to the production of ferro-chromium, ferro-tungsten, ferro-vanadium, etc., by means of ferro-silicon as reducing agent. Fifty per cent ferro-silicon is preferably used, and a basic flux is employed to combine with any excess of silica which may be present in the ore and with the silica derived from the oxidation of the silicon. If the alloy shall be of very low silicon content, slightly less ferro-silicon is used than is necessary for the complete reduction of the ore or concentrate. The process is carried on in a continuous operation, the current passing through a molten bath of a mixture of ore, ferro-silicon and basic flux, and when metal or slag has been withdrawn additional quantities of the mixture are added. It is advantageous to feed the mixture to a bath which is maintained at a temperature higher than is necessary to cause some reaction.

Patent 866,421 relates to the reduction of oxides of vanadium, molybdenum, etc., in two steps. The first step is the partial reduction to a lower oxide by means of carbon or producer gas or water gas, etc. Vanadic oxide, for instance, is reduced by means of carbon according to the equation $V_2O_5 + 2C = V_2O_3 + 2CO$. The second step is the reduction of the lower oxide to the metallic state in an electric furnace with silicon, ferro-silicon or aluminium as reducing agent. This final reduction, using either silicon or aluminium, is represented by the equations $2V_2O_3 + 3Si = 4V + 3SiO_2$ and $V_2O_3 + 2Al = 2V + Al_2O_3$.

According to patent 866,562, vanadium ores, for example, oxides or roasted sulphides or concentrates are reduced in the presence of iron, preferably by the use of silicon, aluminium, etc., the products being commercial ferro-vanadium and a slag containing compounds of vanadium, silicon, etc. The slag is then smelted in the presence of iron and an excess of a reducing agent to wit: aluminium, silicon etc., or when the slag contains compounds of both vanadium and silicon, sufficient carbon or calcium carbide to reduce both of these metals. The product of this second step is ferro-vanadium containing aluminium, if the latter was employed as reducing agent, or silicon, etc. The ferro-vanadium containing silicon or aluminium is then smelted with a vanadium ore or concentrate, whereby a further quantity of vanadium is produced and the silicon or aluminium is eliminated, the products being commercial ferro-vanadium and a slag containing vanadium. This slag from the third step is then smelted in the presence of iron in the same manner as described for the second step. In practice the second and fourth steps of the process may be combined.

Manganese Silicide.—E. F. Price, 866,597, Sept. 17, 1907. Application filed Nov. 14, 1905. Assigned to Electro Metallurgical Co.

A charge of compounds of manganese and silicon is smelted in an arc furnace, carbon being added to the charge in sufficient amount to not only reduce the manganese and silicon but also to protect the carbon electrodes from oxidation. A considerable body of the charge is maintained around the depending electrode or electrodes, and the reduction, withdrawal of the product and supply of the charge mixture are conducted as a continuous operation. The potential difference between the electrode terminals is kept at the minimum value requisite for the maintenance of an arc, to prevent leakage of current through the charge.

Calcium Carbide and Phosphorus.—J. T. Morehead, 862,092 and 862,093, July 30, 1907. Application filed Oct. 14, 1895. Assigned to Willson Laboratory Co.

Calcined bones or phosphate rock are treated in an electric arc furnace to produce simultaneously phosphorus and calcium carbide. One hundred pounds of phosphate rock, consisting chiefly of tricalcic phosphate, are mixed with 55 pounds of coke or charcoal and 8 pounds of lime, and are finely ground. The mixture is treated in an electric arc furnace through which a reducing hydrocarbon gas is passed. The reaction is

$$Ca_3(PO_4)_2 + 14C = 3CaC_2 + 8CO + 2P.$$

The phosphorus distills over and is won in the condenser F,

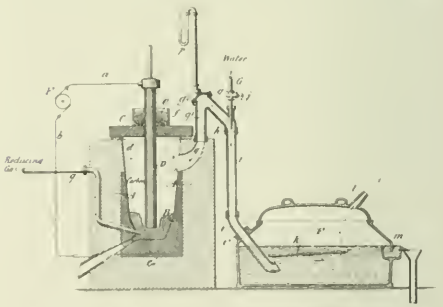


FIG. 1.—ELECTRIC FURNACE FOR PRODUCTION OF CALCIUM CARBIDE AND PHOSPHORUS.

while the carbon monoxide passes off through 1. The calcium carbide won in this process is not pure but is a phosphoric or phosphorized calcium carbide. The phosphorus exists in the form of calcium phosphide, which is intimately combined with the carbide. In contact with water both acetylene and phosphorus are liberated. The latter is ignited spontaneously by the heat of combination and burns to phosphoric acid. The phosphorized carbide is therefore a very dangerous substance to handle or store, but is useful for special purposes, for instance, for illuminating a distant point on a body of water at night. A cartridge or shell charged with this material might be fired from a gun under such conditions as to liberate the material on striking the water. The carbide would then instantly begin to generate acetylene gas, which would be ignited by the phosphide, and if the mass were made to float the reaction would continue until all the carbide was decomposed, so that a brilliant illumination could be maintained for a considerable time.

Manufacture of Electric Resistance Bodies.—F. Bölling, 864,723, Aug. 27, 1907. Application filed Dec. 29, 1904. Assigned one-half to Chem.-Elec. Fabrik Prometheus.

Carborundum or carbide of boron or siloxicon or similar materials are converted into a coherent mass suitable for resistance bodies, at a temperature below their melting point. This may be done in a suitable eletric resistance furnace, the

product obtained being of a porous nature. In order to increase the mechanical strength of the bodies they may be dipped in enamel and then fired in a suitable furnace. This secondary treatment may in certain cases be avoided by adding to the finely pulverized raw material, suitable materials for the purpose of still more firmly cementing the crystals together, for instance, artificial corundum, or a similar material having a high fusing point. The addition of any of such materials has, however, the disadvantage that the fusing point of the resistance bodies is reduced. By an addition of 10 per cent corundum the fusing point is reduced to about 1,500° C. A further disadvantage of such binding materials is that the resistance in most cases becomes too high for some purposes. A specially suitable resistance body is obtained by the addition of boracic acid, which serves simultaneously as a deoxidizing agent and binding material and for the increase of conductivity. The boracic acid is added to the carbide or mixture of carbides, and the mass is pressed together under strong pressure and finally fired at a temperature of about 800° to 1,200° C., but below its melting point. "In a test 9 grams of crystals of silicon carbide and 1 gram of boracic acid were mixed together, the mass then pressed and fired at about 1,200° C. The product showed such a good conductivity that a body of 80 mm. length and 8 x 8 mm. section could be utilized for a tension of 72 volts." Resistors made in this way may be used for starting or regulating resistances, as resistances for arc lamps, as heating resistances, etc. These resistance bodies, made with boracic acid, can be applied for temperatures up to 800° C., but at higher temperatures they become soft, so that in this respect they are inferior to those made of carbide without binding material or with a silicified carbon bond. On the other hand, they possess the important advantage that for their production much cheaper raw materials can be employed because the amorphous carborundum which is used is obtained as a by-product.

Heating Bar for Electric Oven.—A. L. Brougham, 857,381, June 18, 1907. Application filed Oct. 26, 1906.

In electric heaters and ovens heating bars are sometimes used, the central part of which has a high electric resistance and is brought to incandescence by the current, while the terminal portions have a higher electric conductivity and are therefore heated to a smaller degree. The present inventor makes the terminals of 70 per cent carbon and 30 per cent clay, and the central portion of 30 per cent carbon and 70 clay. The terminals are interdigitated, as shown in Fig. 2, which represents a plan and side view; 1 and 2 are the terminals and 3 is the heating portion. These members are interdigitated end to end at A. The digitations in the terminals are in

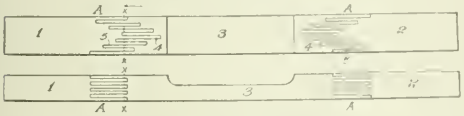


FIG. 2.—RESISTOR CONSTRUCTION.

the form of rectangular bars 4 projecting from the bodies of the terminals and meshing with corresponding digitations 5 projecting from the ends of the central portion 3. The digitations are arranged in a series of vertical rows of uniform length. The rows are disposed in echelon in such a manner that the digits of the terminals extend gradually further and further into the heating portion of the bar from the sides to the middle. Thus the resistance of the bar, considered as a whole, is caused to increase gradually between the body of the terminal and the body of the heating portion, thus avoiding altogether abrupt gradations in the heat of the bar with consequent liability to rupture and injury, due largely to unequal expansion. The entire bar is molded and is built up from several layers, each of a depth or thickness equal to that of its digitations.

Resistors for Electric Heating.—G. Egly, 866,444, Sept. 17, 1907. Application filed Dec. 2, 1905. Assigned to Gebruder Siemens & Co.

A mixture of silicon and carborundum is pressed into the desired form. An agglutinant may be used which is either completely volatilized by the high temperature to which the form is afterwards subjected, or completely or partially left in the mass, for instance, an agglutinant which is carbonized when heated, such as tar or the like. The fashioned form is then heated in an atmosphere of pure nitrogen, whereby the silicon combines with nitrogen and the silicon nitride cements the particles of carborundum strongly together. When an agglutinant that is capable of being carbonized is used, there is formed, according to the proportion of the carbon thus introduced a compound of the composition C_2Si_2N. If a proportion of carbon corresponding with this formula be added to the silicon, there is obtained a very solid mass, which conducts well and consists in the main of the compound C_2Si_2N; this compound, like the silicon nitride, firmly cements the carborundum.

Articles produced in this way can be heated in the open air to temperatures as high as 1,600° C. without being changed in the slightest degree. They are remarkably dense and hard, and may be used for grindstones, etc. Finally, on account of their electric conductivity they may be used as electric heating bodies. "A rod, consisting of C_2Si_2N, as described above, 125 cm. long and 1 sq. cm. in cross-section, has an electrical resistance of about 1 ohm. If the rod be fashioned from a mixture of 70 parts of silicon carbide and 30 parts of silicon and be heated in nitrogen in the manner described, it will have for the above dimensions a resistance of about 20 ohms. If the mass consists of 70 parts of silicon carbide and 30 parts of silicon be mixed with 10 parts of clay, a rod of the same dimensions will have a resistance of about 70 ohms. On the other hand, if silicon carbide were mixed with 10 per cent of clay without any silicon and burned in the ordinary manner, the form produced would have a very high resistance, namely, about 1,000 ohms, and mechanical properties much inferior to those of the forms made with aid of silicon and nitrogen."

Electric Muffle Furnace.—A. L. Marsh, 861,744, July 30, 1907. Application filed Feb. 18, 1907. Assigned to Hoskins Co.

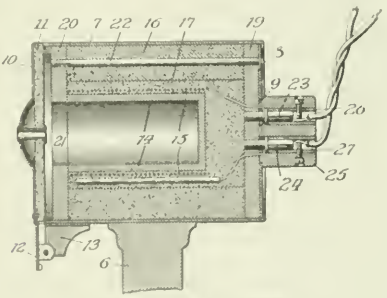


FIG. 3.—MUFFLE FURNACE.

The construction is shown in Fig. 3. The muffle consists of an inner tube 14 of fused magnesia or similar refractory material, about which is coiled a conducting wire 15 of a high electrical resistance and special construction. 16 is a tubular shell of fire clay, and between the two tubes silica or another material which does conduct the heat is packed. A disc 19 of asbestos fiber closes the inner end of the muffle and the disc 20 covers the outer end. The latter has a central opening 21 which forms the mouth of the muffle. Rods 22 fasten the discs 19 and 20 in place. (The commercial form of

The furnace is described in an article on another page of this issue.

Induction Shaft Furnace.—J. S. Edström, 862,140, Aug. 6, 1907. Application filed March 30, 1906.

The diagrams of the furnace, Fig. 4, are almost self explanatory. The lower diagram is a horizontal section on line II, II, while the upper right-hand diagram is a vertical section along the line III, III; 4 is an iron core, and on it is

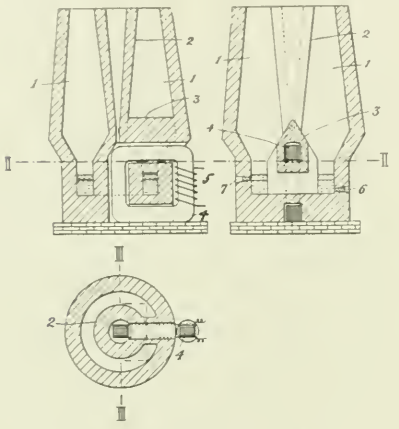


FIG. 4.—INDUCTION SHAFT FURNACE.

wound the primary winding 5 which induces an alternating flux in the core. The fused bath represents the secondary, 7 being the tap-hole for the slag and 6 for the metal. The ores which are smelted are heated on their passage downwards by the uprising gases, and any carbon monoxide gas may be burned in the shaft above the zone of reduction by application of an air blast.

Electric Furnace.—W. G. Clark, 865,016, Sept. 3, 1907. Application filed Dec. 17, 1906. Assigned to Electric Furnace Co., of Portland, Me.

A graphite crucible, has a rounded bottom, and within it is placed a central electrode, also of graphite, which is shaped to fit the bottom and to have for the greater part of its length a higher resistance than its foot and than the furnace walls. For this reason the main stem of the electrode is made relatively thin. The furnace is started by removing the electrode from the bottom of the furnace and thus producing an arc. After the melting has begun the electrode is again brought into direct contact with the furnace walls, and the furnace is operated as a resistance furnace. It seems to be intended for the manufacture of glass.

Electric Smelting Apparatus.—J. C. Young, 865,285, Sept. 3, 1907. Application filed Jan. 16, 1907.

The first claim reads as follows: "In an electric smelting apparatus, a carbon forming one pole and a series of spaced receptacles mounted for rotation in a vertical plane and forming the other pole, whereby an arc is adapted to be established or interrupted between said receptacles, one at a time, and the carbon."

Electric Furnace.—H. N. Potter, 851,961, April 30, 1907. Application filed July 23, 1903.

The claims of this patent refer to the construction of an electric furnace, the corresponding method patent having been already abstracted in our Vol. III., p. 346. The furnace is essentially a combination of an electric tube furnace and an arc furnace.

Electrolytic Processes.

Production of Alloys from Fused Salts.—F. von Kügelen and G. O. Seward, 865,648, Sept. 10, 1907. Application filed May 26, 1905.

When a fused mixture of two salts of different metals, but with the same anion, is electrolyzed the less electro-positive metal is separated before the more electro-positive metal. With salt mixtures having different anions, the decomposition voltage of each salt becomes the determining factor. If the salt of the less electro-positive metal has the higher decomposition voltage, the other salt will be decomposed first and its anions set free at the anode. Its cation, that is the more electro-positive metal, will enter into a secondary reaction with the anion of the less electro-positive metal; but this secondary reaction is in general not complete, and the result at the cathode is in most cases the deposition of an alloy of both metals. When a fused mixture of $MgCl_2$, NaCl and KCl, containing about 13 per cent Mg, is subjected to electrolysis, pure magnesium is obtained. When, however, most of the $MgCl_2$ is replaced by MgF_2, keeping all other conditions the same, an alloy of magnesium with alkali metals instead of pure magnesium is deposited. Electrolyzing a mixture of MgF_2 and $CaCl_2$ results in an alloy of magnesium and calcium with constant separation of chlorine at the anode. The explanation by the authors is as follows: NaCl requires for its decomposition 4.3 volts, MgF_2 requires 4.6 volts, and NaF requires 4.7 volts. Sodium chloride is decomposed first, its decomposition voltage being lower than that of the MgF_2, and the MgF_2 is in turn reduced by the sodium, though this secondary reaction is not complete, because the heat of combination of 2NaF is only a little higher than that of MgF_2. The result of electrolyzing a mixture of MgF_2 and $CaCl_2$ is similarly explained, the $CaCl_2$ being decomposed before the MgF_2, and the MgF_2 being reduced in a secondary reaction by the nascent calcium. The secondary reaction is not complete because the heat of combination of CaF_2 is only slightly higher than that of MgF_2. An alloy of magnesium and calcium is therefore obtained. The authors use this principle for "the production of alloys

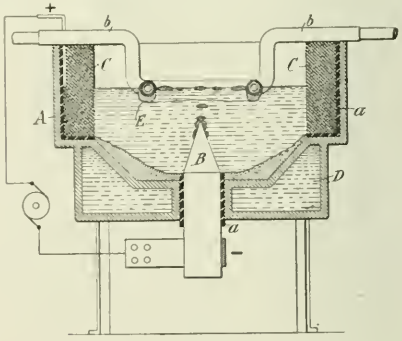


FIG. 5.—CELL FOR CALCIUM PRODUCTION.

from a molten mixture of salts by selecting a compound of the less electro-positive metal having a higher decomposition voltage than the compound of the more electro-positive metal, and so regulating the electrolytic conditions that the secondary reaction between the more electro-positive metal (which is set free first) and the compound of the less electro-positive metal is not complete, but takes place only to the extent necessary for the formation of the desired alloy.

Electrolytic Production of Metallic Calcium.—G. O. Seward and F. von Kügelgen, 864,928, Sept. 3, 1907. Application filed April 25, 1906. Assigned to Virginia Laboratory Co.

The principle is to separate the calcium with a high cathodic current density at a high temperature in molten state, and then

remove it quickly from the hot zone around the cathode into a cooler portion of the electrolyte, since the reduction of its temperature diminishes the danger of the redissolving of the calcium in the electrolyte. The construction of the cell is shown in Fig. 5, where A is a cast iron vessel, B is the cathode of iron or steel, and C the annular graphite anode. The cathode and anode are separated from the iron vessel by layers *a a* of insulating material like asbestos. With the aid of the water jacket D the bottom and exposed portions of the vessel are protected by a chilled layer of the electrolyte. Above and concentric with the cathode B is arranged a water-cooled collecting ring, which chills upon its surface a sufficient layer of the electrolyte to protect it. For this purpose water is circulated through the pipes *b b*. The electrolyte is calcium chloride. The high current density at the cathode causes calcium to be formed in molten globules, which, when they become large enough detach themselves from the cathode and flow to the surface, where they collect within the confining ring and cohere into a mass of constantly increasing volume and of sufficient firmness to be readily removed. The metal is cooled to such an extent that it does not burn by contact with air. From time to time fresh calcium chloride in molten and completely dehydrated state is added. Chlorine is, of course, evolved at the anode.

Copper or Lead From Sulphides.—E. L. Anderson, 862,871, Aug. 13, 1907. Application filed Feb. 23, 1907.

In order to reduce copper or lead sulphides the cell shown in Fig. 6 is used with the electrodes 2 of carbon and an electrolyte E of hydrofluosilicic acid H_2SiF_6. The sulphide ore O to be reduced is placed between one electrode and the perforated wooden diaphragm 3, which is covered with the linen or canvas sheet 4, so as to permit the circulation of the liquid, but intercept the fine particles of the ore. Current is then

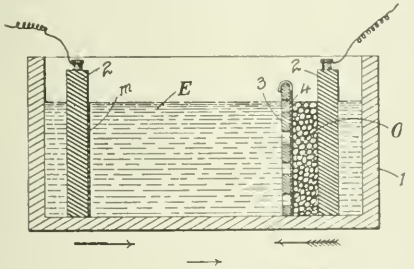


FIG. 6.—REDUCTION OF SULPHIDES

sent through the cell from the left to the right, so that the sulphide ore in contact with the carbon plate acts as cathode, and by cathodic reduction the sulphur in the ore combines with hydrogen and sulphuretted hydrogen is given off. After all the sulphide has thus been reduced the current is reversed and the copper now goes into solution as $CuSiF_6$, and is then deposited as a pure copper sheet M on the other electrode. An advantage of the electrolyte used (for instance, over sulphuric acid, which is employed in the similar Salom process) is said to be that the electrolyte dissolves only the metals to be recovered while it has little affinity for ferric oxide and sulphide. If they are contained in the ore they are not reduced by the nascent hydrogen, and will not pass subsequently into solution, but will precipitate themselves in an insoluble form to the bottom of the tank.

Electrolytic Production of Copper from Ores.—R. Lamb, 852,438, May 7, 1907. Application filed Dec. 22, 1902.

According to claim 1, the process consists "in reducing the ores to granular condition, then placing said ores within a closed leaching vessel, then introducing water and placing liquid SO_2 into said vessel whereby free sulphurous acid will be formed and a solution of the copper thereby effected, then pneumatically separating said solution from the residue, then washing said residue and preserving said washings, then subjecting said solution as an electrolyte to a current of relatively low density between insoluble anodes and cathodes maintaining an excess of sulphurous acid in said electrolyte whereby the same will be oxidized to form free sulphuric acid, then re-employing said electrolyte depleted from copper for leaching fresh charges of ore."

Gravity Cell.—G. Rambaldini, 861,226, July 23, 1907. Application filed Jan. 28, 1902.

The anolyte and catholyte of a double-fluid electrolytic cell are held separate from each other by means of a solid impermeable partition. The necessary electric connection between the two solutions is made by means of a third solution of much lower specific gravity than the other two and placed on top of the other two. The arrangement is essentially the same as in the inventor's former patent, which was abstracted in our Vol. III., page 112.

Electrolytic Apparatus for Reduction of Metals.—C. E. Robertson, 861,319, July 30, 1907. Application filed July 30, 1906.

The chief features of the inventor's "electrolytic furnace" are that the cathode is formed by a crucible with an interior lining of carbon while the anode consists of vertical carbon tubes suspended from a disc which is revolved during electrolysis to provide stirring and prevent the surface from freezing.

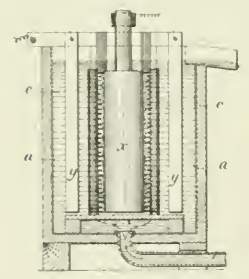
Electrolytic Production of Glycolic Acid.—O. Liebknecht, 837,083, Nov. 27, 1906. Application filed June 14, 1906. Assigned to Roessler & Hasslacher Chemical Co.

Oxalic acid in sulphuric acid or hydrochloric acid solution is reduced electrolytically nearly quantitatively and with very good current yield, if electrodes having a high cathodic overvoltage—such as a lead electrode—are used together with a diaphragm to separate the anodic and cathodic liquors. The cathodic liquor is to be stirred during electrolysis, and care has to be taken that not too dilute acid is used. The following instructions are given; 700 parts of crystallized oxalic acid are dissolved in about 3,300 parts of water, and 1,100 parts of 30 per cent sulphuric acid are added while stirring. This solution forms a cathodic liquor, which it is of advantage to keep warm during the process of electrolyzation. The cathodic liquor should be placed in the cathodic compartment of a suitable electrolytic apparatus provided with a suitable diaphragm, and the anodic liquor, comprising a 30 per cent sulphuric acid is placed on the other side of the diaphragm. The density of the current at the cathode may vary greatly, for instance, from 25 to 250 amps. per square meter of surface of cathode. The presence of the diaphragm in connection with the use of a not too dilute acid largely prevents the anodic oxidation of the oxalic acid. On completion of the electrolysis the anodic solution may be used in preparing a fresh charge of the cathodic liquor. The sulphuric acid can be replaced by about 20 per cent hydrochloric acid. If sulphuric acid is used, glycolic acid is obtained from the electrolytic solution by neutralizing the latter with lime under stirring until all the sulphuric acid and oxalic acid are neutralized. In order to remove the last traces of sulphate of calcium, the inventor uses barium carbonate and oxalic acid in the usual way. In case hydrochloric acid is used instead of sulphuric acid during electrolysis it is only necessary to evaporate the hydrochloric acid in order to get glycolic acid.

Electrolytic Production of Seamless Iron Receptacles.—T. A. Edison, 850,912 April 23, 1907. Application filed Oct. 5, 1903.

The object is to produce by electrolysis seamless iron cans, nickel-plated on the inside, for use as cans for the Edison alkaline battery. Three plating tanks are used. In the first, a thin copper deposit is obtained on revolving hollow brass or copper molds in the following way: The mold is covered

with a very thin layer of paraffine wax not more than 0.005 or 0.025 inch in thickness. Graphite is then applied to the surface in finely divided form so as to entirely coat the mold, the coating of wax being so thin that the graphite apparently makes contact through the same with the mold. The coated mold is now placed in a copper bath with copper anodes, and is copper-plated to a thickness of about 0.004 inch. The solution may be the ordinary copper sulphate solution. The mold is then removed and washed and introduced into a second tank containing a nickel ammonium sulphate solution. Here the mold receives an extremely thin coating of nickel about 0.001 inch in thickness. The mold is then removed and washed and put into the third tank containing a ferrous-ammonium sulphate solution $Fe(H_4N)_2(SO_4)_2$ with iron anodes. The iron solution should be absolutely neutral and free from ferric salts. It may carry from 12 to 15 per cent of the double salt. To prevent the solution from becoming acid, small quantities of ammonia or other alkalies are added at suitable intervals. The plating of iron is effected by a current of 1 to 1.2 amp. per square decimeter. The plating is continued for from 30 to 35 hours at a temperature of not below 40° C., thereby giving a coating of about 0.020 inch in thickness. In order to prevent the formation of pits or holes in the deposited iron coating, which would be likely to form by the accumulation of gas bubbles thereon, and in order to secure a very smooth surface a quantity of crushed charcoal is introduced into the solution, whereby the added material will rub over and scour the surface of the deposited metal to polish the same and wipe off any gas bubbles which may tend to accumulate. A small percentage of carbon will in this way be incorporated with the deposited iron, which, therefore, in the subsequent annealing is converted practically into a superior product of soft steel containing almost 0.4 per cent of carbon. The particles of charcoal may vary in dimension between 1/16 and 1/8 of an inch, and good results are secured when the bulk of charcoal introduced is about one-half the bulk of solution. During the iron plating the mold is revolved at a speed of about 90 turns per minute. The mold is then removed from the tank and washed in water at a temperature of about 75° C., thereby melting the wax originally deposited on the mold. The deposited can is then removed from the mold and is annealed by heating it to a red heat in a closed retort containing a non-oxidizing atmosphere such as hydrogen gas. After annealing the articles are allowed to cool in the same atmosphere. Finally the copper originally deposited on the graphite is removed by filling the can with a solution of copper nitrate and sodium nitrate and using the can as anode against a copper cathode.



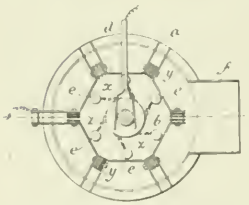


FIG. 7.—ELECTROPLATING WITH HIGH-CURRENT DENSITY.

Electrolytic Deposition of Copper.—H. C. Harrison and J. Day, 858,341, June 25, 1907. Application filed Aug. 7, 1902.

Much higher current densities than are usual become practicable if the layer of electrolyte right next to the cathode surface is continually renewed. This is done by the inventors as shown in Fig. 7, when the object is to get a tough, smooth and homogeneous deposit of copper in form of a tube, which is directly of commercial utility without having to be recast; or it may be cut so as to give a sheet; x is the cathode on which the deposit is to be produced. It is revolved by means of the spindle b, and the current is introduced through the brushes d. As anode a number of copper bars y are used placed around the cathode; ee are series of vertical pipes spaced about equidistant from one another and disposed concentrically around the cathode x and parallel to its longitudinal direction. These vertical pipes ee are provided at frequent intervals with holes or nozzles in such a position that they will direct jets z of electrolyte in a direction tangentially to the surface of the cathode.

Plating Apparatus.—D. F. Boderick, 858,059, June 25, 1907. Application filed Aug. 10, 1906.

In order to utilize to the fullest extent an endless carrier in an electroplating plant, two superimposed platforms are provided with a number of tanks on each of them containing the various baths which it is desired to use in the plating process. The endless carrier travels over both series of tanks, the work to be plated being suspended from the carrier. Arrangements are made to let the carrier rise and descend so as to dip the work successively in the tanks of the upper series, and then to dip them successively in the tanks of the lower series when the articles held by the carrier are traveling toward the starting point. In this way the return travel of the carrier is utilized in the plating process.

Anode for Electroplating.—A. J. Deloye, 858,160, June 25, 1907. Application filed Jan. 31, 1907.

The anode comprises "a body portion or core of gradually diminishing taper from its upper to its lower end, said core being substantially oval or elliptically-shaped in cross-section and having a series of integral outwardly-projecting obliquely disposed spurs or projections formed one above the other and on the narrow edges or sides of said body portion, said projections being of gradually decreasing length from the upper to the lower end of the anode." The object of the construction is to increase the working surface and the dissolving action of the anode.

Nickel-Silver Plating.—R. H. Marshall, 850,944, April 23, 1907. Application filed Oct. 18, 1906.

Plating with an alloy of silver and nickel has the advantage that it is cheaper than plating with pure silver, that it gives an unusual lustre and reduces the liability of corrosion or tarnishing. The electrolyte consists of a solution of 1½ ounces of double cyanide of nickel and the same amount of double cyanide of silver or chloride of silver, in 1 gallon of water. Pure silver anodes are used and the bath is replenished from time to time with additions of double cyanaide of nickel.

Making an Abrasive Body by Electroplating.—E. G. Case, 12,567, Nov. 27, 1906. Application filed Jan. 10, 1905.

In order to provide an abrasive surface which is practically inherent in the body to which it is applied and therefore has high wearing qualities and permanency, the abrasive substance, such as carborundum, emory, etc., is powdered on the surface, while the latter is simultaneously subjected to an electroplating process. A metal coating is thereby deposited over and around the particles of the abrasive material and permanently fixes the abrasive material to the underlying body, since the abrasive particles become embedded in and fastened by the plating.

Electroplating Apparatus.—A. F. Schroeder, 866,311, Sept. 17, 1907. Application filed March 18, 1907.

Details of construction and mounting of a tumbling drum for electroplating with an axial shaft for revolving the drum.

Electrolytic Purification of Liquids.—J. T. Harris, 857,277, June 18, 1907. Application filed June 20, 1903.

An electric current is passed through the water or liquid to be purified, and the liquid is simultaneously subjected to the action of a magnetic field. The anodes are of a magnetic

metal which yields an insoluble, flocculent hydroxide, such as iron. "The magnetic field, acting upon the iron anodes and the liquid in contact with them, increases the volume of hydroxide produced by the electric current. This hydroxide combines with and coagulates the organic matter in the water, and the coagulum is subsequently removed by sedimentation or filtration, or both. The water is preferably agitated and thoroughly aerated during treatment, by injecting upward through it streams of filtered air, which may be partially ozonized. In some cases, especially when the water contains free acid, coagulation and removal of the impurities is facilitated by the introduction of a suitable reagent, before, during or after the electrolytic treatment."

Electrolytic Cell.—A. O. Tate, 857,909 and 857,910, June 25, 1907. Application filed Sept. 28, 1904.

The apparatus appears to be intended for electrolytic purification of water. The peculiar construction of the cell is indicated by the first claim of 857,909, which relates to "an electrode for an electrolytic cell embracing positive and negative conductors of relatively good conductivity, located closely adjacent to each other and mechanically and electrically separated by an insulating medium, the lateral edges or faces only of the conductors being exposed to the electrolytic solution, so as to constitute an electrolytic field therein."

Purifying Water.—A. O. Tate, 860,771, July 23, 1907. Application filed July 27, 1904.

In this patent apparatus is described, the essential feature of which is the alleged separation and disintegration of solid matter from water through the combined agency of electrolytic action and power-driven separating devices successively actuated.

Treating Liquors by Electricity.—C. H. C. Koch, 859,178, July 2, 1907. Application filed Sept. 5, 1902.

In order to age alcohol beverages or liquors he puts them in a barrel which contains two plates at both ends. These plates are used as electrodes. The 500-volt traction current is said to be particularly suitable; the treatment may last about a day or less or more.

Ameliorating and Sterilizing Liquids.—V. Dorn, 855,440, June 4, 1907. Application filed Jan. 25, 1904.

To ameliorate or age wines and spirits or to sterilize liquids the inventor uses a process "consisting in saturating the liquid with oxygen and simultaneously passing an electric spark through the liquid."

Plating Separators. P. R. Greist, 854,943, May 28, 1907. Application filed March 13, 1907.

In plating small metallic articles a number of them are usually strung on holding wires. To have them at a proper distance from each other the inventor uses little separating devices which consist essentially of a piece of wire of a length approximately equal to the distance between the articles. The wire has at each end an eye, so that it may be strung on the holding wire between the articles. The eyes are so bent as to form only small points of contact with the articles to be plated.

Batteries.

Making Nickel Films or Flakes.—T. A. Edison, 865,687 and 865,688, Sept. 10, 1907. Application filed Jan. 19, 1907. Assigned to Edison Storage Battery Co.

For making films of metallic cobalt or nickel, Mr. Edison uses a copper cylinder with a polished nickel plated surface, which is first immersed in a suitable cobalt plating bath, such as a concentrated solution of cobalt chloride with cobalt anode, and while the cathode is rotating an exceedingly thin film of cobalt, 0.0001 inch or less in thickness, is plated on the cathode. This is then washed and placed in a solution of copper sulphate containing about 2 per cent by volume of iron sulphuric acid, whereby the cobalt is caused to go into solution and the copper is deposited as cement copper in a granular but slightly adhesive form. The cathode is then placed in a copper plating bath of copper sulphate solution with copper anodes and an electro-deposit of copper, 0.003 to 0.0035 inch thick, is obtained on the cement copper while the cathode is rotated. It is then washed and introduced into a nickel bath consisting of a concentrated solution of nickel chloride with nickel anodes. A film of nickel 0.0002 inch thick is deposited on the copper. The cathode is again washed and a second film of copper 0.0001 inch thick is deposited. Then nickel is again deposited, and so on, alternating layers of copper and nickel being deposited until a composite sheet of the required thickness is secured. This sheet is cut longitudinally of the cathode and the sheet is cut up into strips, 10 inches long and 1/16 inch wide. These filaments are placed in a basket and introduced into an ammoniacal solution of copper sulphate (80 per cent ammonium hydrate, 5 per cent copper sulphate crystals, 5 per cent ammonium chloride and 10 per cent water) and moved up and down in this bath. The copper is thereby dissolved while the nickel or cobalt is not attacked, so that the nickel is obtained in the desired film or flake form.

Storage Battery. T. A. Edison, 850,913, April 23, 1907. Application filed Nov. 28, 1902.

The object is to provide a relief valve and a gas separator, permitting the escape of gas generated during the charge of a battery and at the same time to separate from it any solution which may become mechanically entrained with the gas. The escape of the solution is thereby prevented while the explosion of any gases by outside sources is rendered impossible. The devices consist "of a gas-vent in the can, a dash-plate and a gauze like or perforated diaphragm arranged in the escape vent and through which the escaping gases pass." The gauze operates like the gauze of a safety lamp, while the dash-plate causes any gases which may escape from the cell to be diffused and diluted so as to burn with difficulty.

Battery Electrode. T. A. Edison, 860,195, July 16, 1907. Application filed April 28, 1905.

The object is to reduce to a minimum the flake-like material with which the active mass in the Edison battery is mixed for the sake of increase of conductivity. For this purpose the tubular conducting pockets are longitudinal corrugated after the active material has been introduced within the same. The latter is thereby more closely packed together to increase the area and contact between the active mass particles and the conducting flakes and the conducting walls. Furthermore, the pocket is made elastic so that it may accommodate variations in bulk of the active mass and at the same time a substantially continuous elastic pressure is applied on the active mass.

Making Seamless Battery Cans. See the abstract of a patent of Edison above, under Electrolytic Production of Seamless Iron Receptacles.

Storage Battery. T. A. Edison, 852,424, May 7, 1907. Application filed Nov. 23, 1902. Assigned to Edison Storage Battery Co.

Mechanical details of construction of his battery.

Edison-Lalande Cell. T. A. Edison, 858,802, July 2, 1907. Application filed Jan. 10, 1900.

In the Edison-Lalande cell, zinc and copper oxide electrodes are used in potassium hydrate. In a modification which may be used as a secondary battery nickel hydroxide is used as depolarizer, while a plate of metallic magnesium is employed to receive the zinc deposit plated out of the alkaline zincate solution by the charging current. The present patent refers to the addition of silicate of potash to the electrolyte, whereby the solvent power or the capacity of the solution for zinc is very largely increased and may be more than doubled than when potassium hydrate alone is used. In the Edison-Lalande cell the best composition for the electrolyte is to add to a 20 per cent hydrate solution about 15 per cent of potassium silicate. In the modification in which nickel hydroxide is used the proportions of potash and of the alkaline silicate can be conveniently increased, since there is less likelihood of the

...ation freezing than with a primary battery which is often used in more exposed places.

Storage Battery.—O. F. Harvey, 853,877, May 14, 1907. Application filed Aug. 11, 1905.

In order to provide for expansion and contraction of a battery plate, it is made up of blocks of active material arranged one above the other. A flexible conducting strip is wound around these plates so as to be in contact with three sides of each of these blocks; it terminates in a lug extending from the upper end of the plate. A supporting frame surrounds the blocks and the conductor, and upon the top of the blocks and primarily spaced a distance below the top of the frame a plate rests which is moved vertically by means of guides during the expansion and contraction of the active material. Elastic means (like rubber bands) are provided which do not hold the plate in close contact with the top of the active material.

Pasted Positive Electrodes.—H. Fredet, 854,940, May 28, 1907. Application filed Jan. 2, 1904.

The inventor recommends to mix the lead oxide used in making the paste with ammonium hydrosulphide. This is stated to result in dense coherent plates and to have other advantages.

Storage Battery.—W. Gardiner, 864,297, Aug. 27, 1907. Application filed Dec. 23, 1905.

Claim 1 reads as follows: "In a storage battery, the combination of a series of trough-like juxtaposed sections, each open at one side and having another of its sides provided with apertures contiguous to the next adjacent section; a porous strip covering said apertured side of the inner side thereof; the active material bearing against said strip within the section and a porous strip covering said open side, said sections having means interposed between them for holding the last said strip in place, and forming passages for the electrolyte between the two aforesaid strips."

Storage Battery.—L. Chronik, 861,806, July 30, 1907. Application filed Jan. 2, 1907.

Details of construction of a battery plate of the Plante type. The first claim refers to "an electrode for secondary batteries, comprising pairs of plate sections, each section comprising a bar having secured thereto spaced strips elliptical in cross-section and provided on each side with integral oblique ridges, the ridges on one side running in the opposite direction to the ridges on the other side, said strips being arranged with their widest dimensions transverse to the bar, the strips of one section being arranged between the strips of the other section."

Storage Battery.—W. Gardiner, 860,291, July 16, 1907. Application filed May 20, 1905.

"The active material is placed in a plurality of independent holders, and these in turn are placed within a cage, which constitutes the body of the plate, and which may be duplicated or repeated in the battery as often as need be for creating a plate of the desired size, and between the cage and the holder, or at other point between the active material and the cage, is placed a diaphragm or sheet of porous material which will absorb the liquid of the battery and allow the same to have free access to the active material while preventing the detached particles of the latter from finding their way into the bottom of the cell or other place where they are liable to collect and short circuit the battery."

Storage Battery.—J. Diamant, 859,753, July 9, 1907. Application filed Nov. 28, 1906.

Ordinary negative spongy lead plates lose after some time their capacity, because the porosity at the outside surface is diminished, although the inner particles of the active mass still retain their porosity. To overcome this trouble the inventor simply turns the active mass around so that the inner mass later becomes the outside surface, one or more sectional planes being provided parallel to the surface for this purpose. Claim 1 relates to a process for prolonging activity of spongy lead plates for electric storage batteries, which consists in dividing the plates into sections and then varying the relative order of the sections to bring the internal surfaces to the outside and the deteriorated surface to the inside."

Storage Battery.—J. Knobloch, 865,503, Sept. 10, 1907. Application filed Dec. 26, 1906.

The plate is of the pasted type, and the active material is held firmly to the support by enclosing it in perforated hard rubber envelopes.

Primary Battery.—Charles E. Hite, 851,353, April 23, 1907. Application filed May 17, 1906.

Details of construction of a battery, consisting of a series of cells in one receptacle, in connection with a common reservoir for the electrolyte, so that the latter may be supplied to the cells when they are to be used, or may be removed when not to be used, so as to prevent local action at the electrodes.

Primary Battery.—W. P. Divine and A. J. Shinn, 859,437, July 9, 1907. Application filed Aug. 1, 1906. Assigned to Decker Electrical Manufacturing Co.

One side of the battery contains a hollow conduit connected to several rows of porous tubes, the other ends of which are inserted in a solid graphite header. Graphite rods within the porous tubes, and set in the solid graphite header, represent one set of electrodes. The hollow conduit and the porous tubes represent communicating compartments for the circulation of the electrolyte. Vertical zinc plates at both sides of the rows of porous tubes represent the other set of electrodes.

Battery.—B. B. Downs, 855,880, June 4, 1907. Application filed April 2, 1906.

The bottom of a containing box is filled to a depth of half an inch with a layer of melted wax or any other suitable insulating sealing compound. The cells are then placed on this layer and the electrical connections are made; a melted wax or other compound which melts at a lower temperature than that of the insulating material on the floor, is then poured into the box until the cells and their connecting wires are entirely submerged.

Dry Battery.—C. D. Manville, 852,188, April 30, 1907. Application filed Nov. 20, 1906.

In order to avoid the impairment of batteries used on automobiles, the battery is cushioned so as to avoid undue jar and agitation. For this purpose a coil spring is provided within the casing below the battery.

Dry Battery.—S. Cochrane, 851,402, April 23, 1907. Application filed Jan. 19, 1906.

The zinc cup is embedded in a cover of absorbent fibrous material, the outer side of which is impregnated with a waterproof and acid-proof insulating compound, such as an asphaltum compound or a petroleum compound, while the inner side is left absorbent and is impregnated with the electrolyte.

Battery Cover.—A. H. Marks, 859,091, July 2, 1907. Application filed Sept. 12, 1906.

The cover for battery cells or boxes comprises a rigid plate of hard rubber with a continuous flange of soft rubber, extending along the entire edge and depending from it so as to enclose the upper end of the box.

Discharges Through Gases.

Fixation of Atmospheric Nitrogen.—C. P. Steinmetz, 865,618, Sept. 10, 1907. Application filed April 20, 1907. Assigned to General Electric Co.

In order to produce nitrous compounds from atmospheric air, the air is exposed to the action of an electric arc of minimum volume and greatest practical length. For this purpose a single electric arc, maintained by a direct current, is deflected or drawn out latterally by magnetic means, like in the Birkeland-Eyde process. But contrary to the practice in the latter process, the arc is not broken but is drawn out only to a distance within which it can be safely maintained. It is simultaneously magnetically rotated within its sphere of action so

that it sweeps through the air which is converted into nitrous compounds. The rotation serves the double purpose of extending the sphere of action of the arc and of limiting the time within which the arc acts upon any portion of the air passing through the converting chamber. The rotation of the arc may be produced by a rotary magnetic field generated in the well-known manner by means of polyphase currents.

Sterilization of Water by Ozone.—M. Otto, 837,107, Nov. 27, 1906. Application filed July 1, 1904. Assigned to American Ozone Co.

Details of construction of a sterilizing apparatus using ozone. The ozone or ozonized air is drawn into the apparatus by the action of the same stream of water which is to be sterilized. The regulating and setting in motion of the stream of water and the stream of ozone are performed by hand or automatically by means of one and the same mechanical contrivance. The same regulating apparatus regulates the operation of the ozonizer, so that when sterilization stops the electric current in the ozonizer is also broken.

Ozone Generator.—J. W. Moliere, 852,133, April 30, 1907. Application filed July 18, 1906.

Details of construction of an electrotherapeutical instrument for the production of ozone and means for supplying it to patients.

MISCELLANEOUS.

Making Homogeneous Bodies of Tantalum.—M. von Pirani, 848,600, March 26, 1907. Application filed Oct. 4, 1906. Assigned to Siemens & Halske Co.

To make homogeneous bodies of tantalum, formerly tantalum powder was formed into a sufficiently solid body by pressing it together and by passing an electric current through the mass, it was fused together. This patent refers to fusing of tantalum by cathode rays. The glass vessel *a* in Fig. 8 is tightly closed by means of metal covers *b* at two opposite ends. The copper cover serves as cathode and carries a reflector-shaped cathode-ray emitter *c*, in the focus of which the metal *d* lies which is to be melted and which is connected to the anode. The vessel *a* is exhausted of air to the extent required for cathode radiation. The metal, which is preferably powdered, melts very quickly under the action of the cathode rays. The cathode rays may easily be moved from the outside by the aid of a magnet in such a way that all parts of the material to be melted are successfully struck by the rays. The method is clean and requires no mechanical device within the tube.

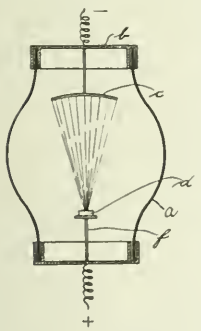


FIG. 8.—MELTING WITH CATHODE RAYS.

Ductile Tantalum.—M. von Pirani, 850,385, Sept. 17, 1907. Application filed June 23, 1906. Assigned to Siemens & Halske Co.

Tantalum hydride, or hydrogenated tantalum, is produced by passing a mixture of vapors of tantalum chloride with hydrogen through a vessel containing an incandescent filament of tantalum. Tantalum hydride forms on the glowing filament in the form of scales. If this tantalum hydride is then heated in a vacuum and the vacuum is maintained by pumping off all gases which are given off, technically pure ductile tantalum is obtained. Since tantalum hydride is a good electric conductor, the heating may be done by passing a current through. The substance melts readily in the electric arc.

Rectifier.—O. Rothenstein, 864,695, Aug. 27, 1907. Application filed Nov. 1, 1906.

An aluminium cup, filled with a potassium phosphate solution and water-cooled from the outside, forms one electrode. Within this solution and insulated from the aluminium vessel is placed a vessel consisting of some "inert" or "passive" conductor like lead, cast iron or carbon, filled with dilute sulphuric acid. A platinum point dipping into this solution forms the other electrode.

Electrolytic Rectifier.—A. S. Hickley, 861,281 and 861,282, July 30, 1907. Applications filed Feb. 7, 1907, and April 16, 1907.

In an electrolytic rectifier, such as containing a solution of ammonium phosphate and an aluminum electrode, it is necessary to prevent undue heating of the cell. In patent 861,281 the electrodes are provided with large loops extending beyond the top of the electrolyte and exposed to the atmosphere for the purpose of diffusing heat into the atmosphere. Patent 861,282 refers to special construction of the electrodes. The first claim reads as follows: "In an electrolytic cell, the combination with a receptacle for containing an electrolyte and forming a hollow electrode, a supplemental electrode within and in electrical contact with said hollow electrode, and a hollow member connected to the hollow electrode."

Magnetic Separation.—H. H. Wait, 861,782, July 30, 1907. Application filed March 20, 1905. Assigned to International Separator Co.

A mixture of particles which are so nearly alike in magnetic permeability that they cannot be directly separated in a magnetic separator, are subjected to a preliminary treatment which changes the magnetic characteristics of one constituent without affecting the others. For instance, a mixture of molybdenite and mica cannot be completely separated in an ordinary magnetic separator, but the mica differs widely from the molybdenite in its physical characteristics, notably in that it is more porous. To separate such a mixture it is first reduced to a finely divided state, such, for instance, as would pass through a sieve of 14-inch mesh, and is then treated with an iron sulphate solution and heated or exposed to the atmosphere. The mica being porous in its nature, receives and retains upon its surface and in its crevices a deposit of mag-

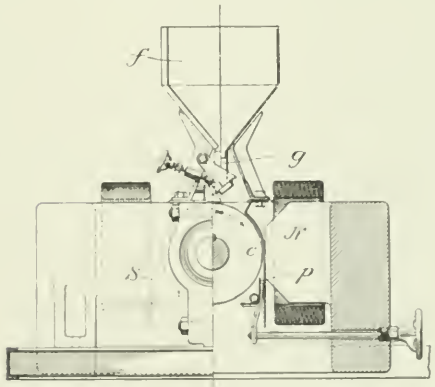


FIG. 9.—MAGNETIC SEPARATOR.

netic permeability [illegible] that magnetic separation from the molybdenite which is not so affected becomes possible. The magnetic separator is shown in Fig. 9, which shows a laminated armature *c* having teeth upon its periphery and arranged to rotate between two opposing magnet poles N S of opposite polarity. The material fed into the hopper *f* on the top is carried around past one of the pole pieces. The magnetic particles are attracted to the teeth of the cylinder

and lead among its constituents until they have passed beyond the influence of the non-magnetic material, which falls straight down over the side of the cylinder. A divider *p* separates the two classes of materials.

Melting Through Masses.—A. E. Menne and W. Zollenkoff, 850,498. Sept. 17, 1907. Application filed Aug. 27, 1906.

It is well known that a metal plate may be cut by first heating it with the oxy-hydrogen flame and then burning the metal along the cutting line with oxygen under pressure. In the present patent the oxygen hydrogen flame is not used. The method of the inventors is a combination of electric heating with the application of an oxygen blast. It is particularly for use in melting holes in armor plate, for forming blast holes, for dismounting masses of iron and steel, for opening tap holes in blast furnaces, etc. A steel plate, for example, say armor plate 10 inches thick, is to have a hole made through it. The one pole of a circuit supplying electric current is connected with the armor plate, and the other pole is connected with an electrically conducting pipe through which oxygen is blown. Now, if the armor plate is contacted by the pipe and if oxygen is simultaneously blown through said pipe, only a flash of the short-circuit spark takes place, but the heat suffices for commencing the fusing and the oxygen perforates the plate in the fraction of a minute. It is here not a question of electric melting, or of a supply of oxygen to the electric arc; the action of the heating by the heat generated electrically and the melting through by means of the current of oxygen take place in point of time one after the other, as the current of oxygen indeed blows out the electric arc, or does not even allow it to form at all.

Blasting Machine.—L. W. Bowman, 848,153, March 26, 1907. Application filed April 25, 1906.

A series of connected storage batteries are housed in a closed casing. The circuit for firing the blast is closed by bringing two plugs in contact with the terminals of the battery. These two plugs are, of course, connected to the firing line. One of these plugs is inserted in a protected opening at one end of the casing, while the other plug is simply made to touch the exposed plate at the opposite end of the casing. By having the one contact point protected, the danger of accidental discharge is avoided. By using more or less cells any number of cartridges may be exploded at a single operation.

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

Iron and Steel.

Properties of Cast Iron.—Max Orthey, in *Metallurgie* for 1907, Vol. IV., page 196, reports the results of an exceedingly careful test to determine the variation of properties of cast iron with its composition. He selected five kinds of pig iron of the following compositions:

	Si.	*Mn*	*S.*	*C.*	*Combined C.*	*% of C in Combination.*
I	2.52	0.80	0.022	3.56	0.30	8.4
II	1.96	0.04	0.019	3.64	0.39	10.7
III	1.50	0.59	0.065	3.42	0.55	16.0
IV	1.12	0.64	0.072	3.32	0.60	18.0
V	1.08	0.72	0.154	3.26	0.99	30.3

Each of these was melted carefully in a crucible and cast into bars in well-dried sand molds, 30 c. m. long and 2, 3, 5, 10 and 15 c. m. in diameter. These bars were allowed to cool completely in the moulds, then broken and sampled by planing off the whole of the fractured surfaces. The same chemical analyses were made as above, and are compared with the analysis of the pig iron used to note the effect of the casting into small or large bars, with the consequent rapid or slow setting and cooling, respectively. The comparison of the five analyses of the pig irons given above show the effect of decreasing silicon or increasing sulphur or both, on the state of combination of the carbon. Comparing each pig iron with the bars cast from it, the bar 10 c. m. in diameter showed practically the same proportion of the carbon as combined carbon as in the pig iron, the smaller bars a two to three times greater proportion of combined carbon, and the larger bar a slightly less. If we assume that the strength increases as the proportion of combined carbon increases, we are led to the conclusion that for thick-walled castings a sulphur content of 0.15 is decidedly advantageous in increasing the proportion of combined carbon.

Next, test bars were cast of a series of eight pig irons in which Mn, S and total C were kept practically constant, but silicon was decreased from 2.34 to 0.97, while sulphur simultaneously increased from 0.064 to 0.146. The percentage of the total carbon present in the combined state rose from 13.7 up to 26.4, and the mechanical tests showed a steady increase of tensile strength until Si 1.20 and S 0.110, and a steady decrease of bending strength. A similar set of eight tests was made with silicon, phosphorus and sulphur constant, total carbon slightly increasing (3.27 to 3.62 per cent), and manganese rising from 0.35 to 1.56. These tests showed this increase of manganese to be practically without effect on the state of the carbon, but to sharply reduce the tensile strength and the bending strength after it exceeds 1 per cent. A similar set of eight tests was made keeping Si, Mn, S and total C constant, but increasing phosphorus regularly from 0.24 to 1.43. The result showed this increase to have practically no effect upon the state of combination of the carbon, but to regularly decrease the tensile strength and the bending property.

The author concludes that if a casting is to have high tensile strength and stiffness, it should contain 20 to 25 per cent of its total carbon as combined carbon, which is attained by it containing 1 to 1.5 per cent of silicon and 0.06 to 0.15 sulphur, according to the thickness of the casting, with Mn about 0.5 and phosphorus 0.2 to 0.5. For high bending strength with low tensile strength, 1.4 to 2.0 per cent silicon, with Mn, P and S as low as possible. For high strength of both kinds choose the mean composition between those indicated.

Herr Orthey has made a careful investigation and contributed some valuable data to the metallurgy of cast iron.

Vanadium Steel.—In *Revue de Metallurgie* for August, Guillet reviews the recent papers of Pütz on these steels, and then adds his own latest observations. His conclusions are that for tempered steels, better tensional properties can be obtained with a steel of 6 per cent nickel and a given percentage of vanadium than from a steel with 2 per cent nickel and the same per cent of vanadium; it is very important to note, however, that carbon appears to damage these higher nickel steels, especially after a quick cooling. It is therefore recommended for steels to be tempered to increase the nickel as much as possible, keeping carbon low and vanadium normal. The proportions recommended are between the following limits:

	Per Cent.
Vanadium	0.1 to 0.3
Nickel	2.0 to 7.0
Carbon	0.1 to 0.3

With carbon 0.16, nickel 6.2, vanadium 0.12, a steel was

obtained which, tempered, gave 10 per cent elongation, 40 per cent contraction of area, elastic limit 146 kg. per square millimeter (209,000 pounds per square inch), and ultimate strength 154 kg. per square millimeter (220,000 pounds per square inch).

Boron Steels.—Guillet has had made, at the steel works at Imphy, France, a series of boron steels with 0.18 to 0.60 per cent carbon, and 0.2 to 1.5 per cent boron. His memoir illustrated by 17 fine photomicrographs, is contained in *Revue de Metallurgie* for August. He started with an electric furnace alloy made from iron oxide and calcium borate, made by Girod, containing C, 2.85; B, 32.10; S, 0.03; P, 0.005. Two series of steels were made one with about 0.2 per cent carbon, the other with about 0.5 carbon. Their analyses were:

	C.	*B.*	*Mn.*	*Si.*	*S.*	*P.*
1.....	0.180	0.215	0.070	0.232	0.012	0.023
2.....	0.224	0.462	0.202	0.163	0.015	0.015
3.....	0.207	0.844	0.600	0.702	0.014	0.013
4.....	0.281	1.514	0.600	0.641	0.005	0.018
5.....	0.475	0.155	0.370	0.283	0.020	0.020
6.....	0.595	0.406	0.205	0.293	0.016	0.023

Steels with higher amounts of boron than the above could not be forged.

Analysis.—The boron was determined quantitatively by dissolving in concentrated sulphuric acid to which hydrogen peroxide was added. This is distilled to dryness, using a condenser, methyl alcohol is added and distilled again to dryness several times. The successive distillates are caught in dilute ammonia, ammonium chloride and magnesium chloride are added and the whole evaporated to dryness. The residue is heated to redness in a platinum dish and washed with boiling water. The residue is magnesia and magnesium borate, and is filtered out, washed, dried, calcined and weighed. The magnesia in this material is then determined as pyrophosphate, or volumetrically, and the boron oxide is then known by difference.

Transformation Points.—In °C.:

	Heating.	*Cooling.*
1.....	750–830–850)	720–800
2.....	780–875	750–850
3.....	780–885	740 (905–875)
4.....	875–925	735 (800–775)
5.....	775	750
6.....	785	760

The conclusions are that boron raises the transformation temperatures, excepting that the point A_{r_3} in cooling, passes a maximum at 0.8 per cent boron, and descends for higher percentages.

Micrography.—After annealing the first series at 900° and the second series at 850°, they showed under the microscope no anomalies, except small grains of a constituent which is black with picrate of soda, and polishes white. This may be a boro carbide of iron of variable composition according to the content of boron and carbon in the steel. When tempered, this special constituent was reduced to traces in the low boron series, but was still present in considerable quantity in the higher boron series.

Mechanical Tests.—The annealed specimens showed increasing strength and decreasing ductility as the boron increased, similar to increasing carbon. The tempered specimens showed remarkable increase in tensile strength and elastic limit, however, with decreased ductility. With 0.8 per cent boron and 0.21 carbon the properties were:

Tensile strength, 175 kg. per m. m.^{2} = 250,000 pounds per square inch.

Elastic limit, 130 kg. per m. m.^{2} = 185,000 pounds per square inch.

Elongation, 4 per cent.

Reduction of area, 10.6 per cent.

These results are most surprising, considering the low carbon. Another unexpected property is that the resistance of this steel to shock (shock test) is double that of normal steel. The higher carbon boron steels were practically worthless after tempering. All the low carbon boron steels after tempering worked well under the cutting tools. All things considered, 0.22 carbon with 0.5 boron, as in steel No. 2, makes the best combination for industrial purposes. It is important to remember that these steels are practically useless in the normal state or forged, but possess these remarkable mechanical properties only in the tempered condition.

Cupola Practice.—In *Stahl und Eisen* for March 6, C. H. Jaeger of Leipzig, writes upon the construction and running of cupolas. He puts it down to start with that 4 to 6 meters is the minimum height which should exist from the tuyeres to the top; an ordinary cupola of 70 to 90 centimeters inside diameter should not have less than 5 meters. This assures good regeneration of heat by the descending material, no flame issuing from the top, and economy of fuel. In German practice, the following outputs are obtained per hour:

Inside diameter.	*Quantity.*
500 mm.	1,000 to 1,500 kg.
600 "	2,000 " 3,000 "
700 "	3,000 " 4,000 "
800 "	4,000 " 5,500 "
900 "	5,000 " 8,000 "
1,000 "	6,000 " 10,000 "

With a cupola of proper height, the coke consumed will be 6 to 7 per cent of the weight of iron melted; it is possible with 7 per cent to get a finely fluid machinery iron. The air should be furnished positively by a rotary blower which can furnish the required amount at pressures up to 1,000 mm. of water gage. The quantity of air required per minute for every 1,000 kg. of iron melted per hour is:

Consumption of coke	7%	8%	9%	10%
Cubic meters of air per minute	11.8	13.8	14.9	16.4

The charges to the cupola should be broken small and the shaft kept always full. The diameter of the tuyere nozzles must be small enough to give the blast sufficient velocity to properly penetrate the charge; 30 meters per second is sufficient for small furnaces, and 50 meters for large ones. Assuming a certain velocity per second and a certain quantity of air to be blown in per second, the quotient will be the total nozzle area. The number of nozzles is then assumed; more will be needed for a large than for a small cupola, and the area of each nozzle is thus found, from which its diameter is calculated.

Copper

Electrolytic Production of Copper.—An article in the *Oesterreichisch Zeitschrift fur Bahnen und Hutte*, and abstracted in London *Electrician*, Sept. 6, gives an account of the methods employed at Medzianka for producing copper by electrolytic means. The product of the mine is divided into rich ore, with 50 per cent of copper, which is separated underground and mixed ore with 10 to 20 per cent containing calcite and limestone. The ore is crushed, mixed with 5 per cent of damp brick earth and moulded into blocks, which are subjected to a partial roasting, with a free access of air, converting the copper into sulphate and oxide. The roasted ore is crushed fine and lixiviated in lead lined tanks, with the spent liquor of the electrolytic baths containing about 5 per cent of free sulphuric acid. A liquor containing about 5 per cent of copper and 1 per cent of free sulphuric acid is obtained. After passage through a filter press, this is electrolyzed in vats of about 35 cubic feet capacity. Insoluble anodes of lead plates in cloth bags and thin copper cathodes are used. A current of 1,000 amperes at 2.5 volts, corresponding to a current density of about 1 ampere per square decimeter of cathode surface, is used, producing metallic copper, free sulphuric acid and oxygen. The deposited copper, about 1.1 gram per ampere hour, is nearly equal to the theoretical amount. The energy consumed per kilogram of copper is 2.28 kw hours, or 3 hp hours. The liquor is exhausted in

about 35 hours when it is returned to the extraction vats for the treatment of fresh ore. The cathodes remain in the bath for about a month, when the deposit (1 in. to 1¼ ins. thick) is removed.

Gold and Silver.

Tube Mills at Guanajuato. Mr. C. Van Law, in the *Mining and Scientific Press*, Aug. 17, gives some data about the Nobe mills running at Guanajuato for the last eight or nine months. The mills are 4 feet 6 inches x 20 feet; they handle about 80 tons of pulp per day of the following grade: — 40, 11.2 per cent; — 50, 11.2 per cent; + 60, 8.9 per cent; — 80, 10.6 per cent; — 100, 16.3 per cent; + 120, 26.1 per cent.; — 120, 0.7 per cent. The moisture is 60 per cent. The grade of the discharged pulp is as follows: — 40, 0.5 per cent; — 50, 1.7 per cent; — 60, 2.9 per cent; + 80, 6 per cent; + 100, 16.2 per cent; + 120, 21.8 per cent; — 120, 51.2 per cent. The mills are kept filled with pebbles slightly above the center, and the wear of pebbles is approximately ¼ pound per ton of ore treated. The life of the silex linings was eight months. The power required by the mill is 60 hp. at the start, which drops immediately to 43 hp. as soon as the mill is at running speed. The operation of the mills has been attended by no difficulty whatsoever, and the mills have given no trouble mechanically since their installation. Mr. Van Law calls attention to the fact that the truth of the supporting tires and the homogeneity of the material of which they are composed, is of great importance, because if the slightest irregularity occurs either as an original defect or during the operation of the mill, bumping of the mill would ensue and cause the destruction of the mill and perhaps its foundation. It was found at Guanajuato, on starting the first mill, that a film of 1/16 inch of sand had accumulated at certain oily spots on the circumference of the tire, and this causes violent bumping, so that the mill had to be stopped and the ring tire carefully cleaned off. These tires are kept at all times carefully cleaned, and a little oil is put on the surface of the tires once or twice a day. As a result, there has not been the faintest bump or vibration about the mills and they run as quietly and smoothly as possible. In order to limit the end motion in the Abbé mill, two guide rollers with vertical axis bear upon the sides of the supporting tire next to the gear end, and earlier users of the mill had trouble with those rollers being worn out quickly by the tendency of the mill to run endwise. At the suggestion of the Abbé Co. experiments were made to cant the friction rollers upon which the tire moves, and it was found that by this adjustment the main tube could be made to float entirely free on its supporting rollers without touching either of the guide rollers at all. The mill ran for three months without touching either guide roller and normally it hardly touches them once a day.

Ancient Gold Mining in Egypt. In the course of an interesting article under this title in *Mining and Scientific Press*, Aug. 17, Mr. C. Herzig gives the following screen analysis of an ancient tailing: Retained on 100-mesh, 1.85 per cent; pass 100 and retained on 160-mesh, 4.4 per cent; pass 160 and retained on 200-mesh, 5.75 per cent; pass 200-mesh, 88.00. This shows that the ancients already practiced what we now designate under the name of slimming, and Mr. Herzig estimates that with oxidized gold ores they must have recovered practically all the gold, with the exception of, perhaps, the very lightest particles. The ore was ground by staves between stones, usually of granite, and the gold was caught on crude tables built of rock, 8 to 10 feet long and about 3 feet wide, which sloped sufficiently to let the water run off freely.

A Cheap Form of Cyanide Plant.—For many small mills the tailings are too high in value to be thrown away, but their owners are averse or unable to spend money for the erection of a permanent cyanide plant. In a paper to be read at the October meeting of the British Institution of Mining and Metallurgy, Mr. C. Hunter gives the specifications for a cheap and portable cyanide plant to fit such cases. He states that this form of plant is largely in use in Southern Rhodesia, and that such plants give good results, last well and are simple and convenient in operation. The contract calls for the complete equipment of a cyanide plant, including all materials and labor, the plant to be delivered free at the nearest railway siding. The plan is to consist of the following: 1. Five leaching vats, 10 feet diameter x 4 feet 2 inches deep. 2. Two solution tanks, 8 feet diameter x 6 feet deep. 3. Two extractor boxes, seven compartments each, the compartments to be 15 x 15 x 15 inches, with 3-inch baffle board partitions. 4. A steam pump, Knowles duplex type with 1½-inch delivery and 2-inch suction. 5. All necessary pipes, valves, fittings and hose necessary for the complete equipment from and to the tailing and solution tanks and extractor boxes, water connections and steam connections, including stop valves. 6. All necessary gratings matting, jute, cloth, manila rope and packing. 7. Distributor tray for raising pipes and hose connections from the leaching vats, with partition and two outlets to the slimes catchers. 8. Two slimes catchers, each 16 x 16 x 16 inches, with baffle board. The leaching and solutions tanks are to be constructed of 22 B. W. G. galvanized corrugated iron, stiffened at the top with 1 x 1 x ¼-inch angle-iron, and rivetted and soldered inside and outside. The extractor boxes are also to be constructed of 22 B. W. G. iron. All solution pipe is to be 1¼ inches, leaching pipe 1 inch, return to solution tank from pump 1½ inches, return from boxes to solution tank 1½ inches; the pipe lines are to be installed complete with all necessary fittings. The gratings for the solution tanks are to be constructed of 1 x 1-inch strips, on 3 x 1½-inch bearers, with perfect sweep sides built in two sections, covered with cocoa matting and jute cloth turned over at the edge and calked with manila rope. The distributing tray and the slime catchers are also to be made of 22 B. W. G. galvanized iron. All galvanized iron work must have at least one coat of Stockholm tar, applied hot. The whole plant is to be supplied, erected and handed over in running order for £300, divided about as follows: Five leaching tanks at 20 = £100; 2 solution tanks at 15 = £30; 2 extractor boxes at £12.10s. = £25; matting and rope, £13; 5 gratings at 7 = £35; piping, £40; cyanide pump, £26.10s.; excavations, foundations, erection, railway fares and carriage, £30.10s.; a total of £300. The author states that the first of these plants was erected March, 1905, has been running constantly and shows no signs of wear. It has paid for itself out of the first two months' profit, and other plants have done the same.

Recent Improvements in Tube Mill Practice.—A source of considerable expense in tube milling has been the use of imported pebbles for grinding. Attempts have been made with more or less success to substitute quartz pieces from the quartzy ores, but up to now pebbles were considered a necessity and were even shipped to remote localities at high cost. An interesting paper on the substitution of pieces of Rand banket quartz in the tube mill has been communicated to the Chemical, Metallurgical and Mining Society by Mr. K. L. Graham, and is published in the *Journal* of the Society for April. The author has carried out comparative experiments by using two tube mills of the same dimensions, one filled with pebbles and the other with pieces of quartz. The tube mills were both 22 feet long x 5 feet 6 inches diameter, and lined with silex blocks, 6 inches x 6 inches x 4 inches, laid on edge; the joints were staggered so as to prevent wear of the lining in circumferential corrugations. Mill No. 1 was an Allis-Chalmers, and mill No. 2, Fraser & Chalmers type, No. 1 being loaded with quartz and No. 2 with Danish pebbles. All other conditions were kept as nearly as possible the same, including revolutions per minute, weight of solids fed 24 hours and percentage of water to solids. The mills ran together for eighty-one days, after which mill No. 2 had to be stopped on account of mechanical defects. The efficiency of the grinding done by the mills was ascertained by the increase in the amount

of material passing through a 90-mesh sieve, between the inlets and the outlets of the tube mills. The following table shows the results for the month of January of this year, and it is apparent that the No. 1 mill, loaded with quartz, gave the highest efficiency. This the mill maintained during the entire run of eighty-one days:

No. 1 Mill—Quartz Fed 171.5 Tons.

Grade.	Entering Tube Mill.	Leaving Tube Mill.
On 60-mesh	68.68	9.73
On 90-mesh	19.57	26.28
Through 90-mesh	11.75	63.99

No. 2 Mill—Pebbles Fed 10 Tons

Grade.	Entering Tube Mill.	Leaving Tube Mill.
On 60-mesh	68.68	11.32
On 90-mesh	19.57	27.24
Through 90-mesh	11.75	61.44

As No. 2 mill had to be stopped at the end of eighty-one days, the question of wear and tear of linings could not be carried to a full conclusion. However, No. 1 mill was kept running and the lining lasted for 140 days, while a similar lining where pebbles had been used gave only a life of 124 days, and was thus shown that the banket quartz pieces were not any more severe on the lining than the round pebbles. The saving in cost obtained by using the banket quartz was considerable, as the 10 tons of pebbles used cost £60, while the 171.5 tons of pieces of banket quartz were sorted, trammed and fed at a cost of approximately 2s. per ton, or a total of £17, thus showing a saving of £43 per tube mill per month. In order to account for the higher results obtained from the mill which was loaded with irregular pieces of quartz, the author gives it as his opinion that a higher percentage of the work done in the tube mill is by impact rather than by grinding, the quartz lumps, on account of their irregular shapes, being lifted higher in the mill, with less sliding amongst themselves and on the lining than in the case with the smooth, round pebbles. When quartz pieces are fed into the mill, some automatic contrivance is necessary for catching the particles which are discharged through the holes in the outlet plate of the tube mill. These particles may amount to about a quarter of a ton per mill per day, and if allowed to go to the shaking baths they will choke up the distributing launders, detach amalgam from the plates and cause endless trouble. The device used by the author is a perforated trommel, which is fixed to and revolves with the tube mill. Buckets are attached to the inside of the periphery which elevate the quartz particles and discharge them into a chute, which carries them by means of a pipe through the bottom of the launder to a convenient receptacle. The author also mentions that by the use of high-priced quick-setting cement he has succeeded in relining a Davidson mill, 20 x 5 feet, in two days and three hours, this being the time elapsed between the stopping and restarting of the mill. In regard to peripheral or central discharge, he remarks that contrary to prediction in the "early days" of tube milling, the majority of mills built for peripheral discharge have been converted to central discharge with beneficial results.

Nickel

Nickel-Tin Alloys.—Guillet publishes in *Revue de Métallurgie* for June a long article on the microscopic and thermo-physical properties of these alloys, which he has studied throughout their whole extent, and finds different results from those previously reported. Twenty alloys were made and completely studied, from 15 per cent tin up to 95 per cent, all being analyzed chemically to fix definitely their composition. The nickel used contained 1.5 per cent of cobalt and 0.3 to 0.4 per cent iron.

With 0.1 per cent of nickel the melting point falls from that of tin, 233°, with the pyrometer used, to 230°; from this eutectic the curve of melting points rises steeply to 645° with 5 per cent nickel and 790° with 10 per cent., then more slowly to 1,021° with 20 per cent, and to a maximum of 1,254°, with 43.55 per cent of nickel. Guillet remarks that this does not correspond to an atomic formula, and is only a solid solution. Thus another of our illusions—that a maximum on the melting point curve corresponds to a chemical formula—is shattered; and we must get to some broader generalization. Above 43.5 per cent nickel the curve slopes downwards gently to a eutectic at 64 per cent nickel, and then rises gradually to the melting point of nickel, 1,495°. Guillet summarizes his work by cataloging the following eight constituents of nickel-tin alloys:

Tin.

Combination $NiSn$.

A solid solution containing 37.5 to 47.5 per cent nickel.

A solid solution containing 57.5 to 62.5 per cent nickel.

An allotropic modification of the latter.

A second modification of the latter.

A non-magnetic solid solution of nickel.

A magnetic solid solution of nickel, from 0.5 to 100 per cent nickel.

Nickel-Lead Alloys.—A. Partevin gives us the first study of this binary system, in *Revue de Métallurgie* for August. Alloys were made with 0.0, 1.5, 10 per cent nickel, and every other 10 per cent up to pure nickel. The melting points of lead and nickel were 327° and 1,484°. The conclusions are that, starting with pure lead the melting point is lowered to eutectic at 323° by 0.07 per cent of nickel; from 0.07 to 7 per cent of nickel the liquid is homogeneous, but at temperatures between 323° and 1,305° crystals of nickel separate out and leave the eutectic. From 7 to 60 per cent nickel the alloys are entirely liquid above 1,305°, but at 1,305° crystals of nickel separate out of the eutectic, and at 323° the eutectic sets. From 60 up to 100 per cent nickel, that metal separates out at temperatures varying from 1,305° to 1,484°, leaving the alloy with 7 per cent nickel, which finally solidifies as above described. The net conclusion is that nickel and lead form no combination, and that while entirely non-miscible in the solid state they are only partially miscible in the liquid state.

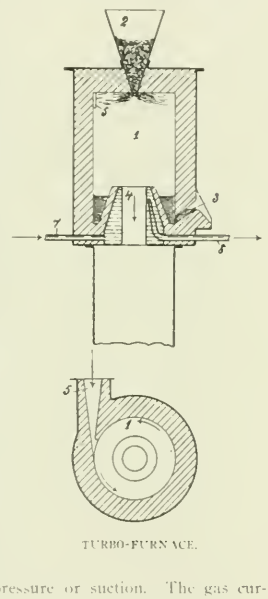
Nickel-Arsenic Alloys. K. Friedrich and F. Bennigson give us in *Metallurgie* IV. (1907), pages 200-216, a fine study of these alloys, accompanied by thirty magnificent photomicrographs. Experts in blow-pipe analysis will recall Plattner's classical process for determining nickel quantitatively by weighing it as Ni^2As, and will appreciate the bearing of these results upon the Plattner test. The alloys were made in an electric furnace, the highest reached being 50.5 per cent of arsenic. As far as investigated, the melting point of nickel is reduced nearly linearly by arsenic from 1,484° (900° at 27.8 per cent. From this eutectic it rises to a maximum of 908° at Ni^2As, 33.5 per cent of arsenic. Then it falls to a second eutectic at 43.3 per cent arsenic, melting at 864° C. Then occurs a second rise to the compound $NiAs$, with 55.7 per cent arsenic, melting at 968°. Ni^2As may occur in some of the mixtures during cooling. Only alloys with less than 2.5 per cent of arsenic are attracted by the magnet.

Peak Load in Electricity Works.—In the London *Electrician* of Aug. 16 and 23 the use of the surplus power of electric stations at hours of light load for electrochemical purposes is advocated. It is stated that the British Carbide Factories Ltd., intend to erect a calcium carbide factory close to the Yorkshire Electric Power Co.'s generating station at Thornhill. "The arrangement which, it is stated, has been arrived at between the two companies provides that only the surplus power of the Power Co. is to be utilized, so that the energy employed for electrochemical purposes will fluctuate according to the load on the power station." It will be interesting to learn how this arrangement will work out.

RECENT METALLURGICAL PATENTS

Iron and Steel

Turbine Furnace.—We recently noticed that Dr C. G. P. de Laval, of steam turbine and cream separator fame is applying the rapid-rotation principle to his electric zinc furnace. He now applies the same principle to iron reduction (801,503, July 30, 1907). A pulverous charge of iron ore, carbon, etc., is introduced continually and uniformly in or near the center of the furnace chamber, and is brought into a rapid rotation by means of a gas or air current which, by pressure or suction, is introduced tangentially at the circumference of the furnace chamber and thus is brought into rotation. The gas or air current is thereby intimately mixed with the charge, which, owing to the influence of the centrifugal force, moves towards the circumference of the furnace chamber from its central inlet, whereas the gas or air current moves in spiral course from its circumferential inlet to its central outlet at the other end of the furnace. The charge and the gas or air current thus move in opposite directions. In Fig. 1, which shows vertical and horizontal cross-section, the furnace chamber 1 is supplied with the pulverous ore charge through the hopper 2. The air or gas is introduced into the furnace through the pipe 5 with great velocity by pressure or suction. The gas current is preferably carbon monoxide or a mixture of air with carbon in a proportion to form carbon monoxide within the furnace. The outlet for the gases is at 4 while the reduced iron is drawn off through 3. The walls of the gas exit 4 are water-cooled, since this diminishes the tendency of dust carried along with the gases to adhere to the walls.



TURBO-FURNACE.

Open-Hearth Process.—In our last issue, page 344, we gave a review of the new steel process of Mr Horace W. Lash. In this connection a recent patent of Mr. Lash (804,972, Sept. 2) is interesting. While the general principle is the same as stated in our former article, the object of the present patent is to make finely-comminuted oxide of iron (magnetic concentrates, iron sands, etc.) available for steel refining, especially in the acid or basic open-hearth process. As described before, the magnetic concentrates are mixed with pig or cast iron (containing a high percentage of metalloids) and carbon and the mixture is finely ground. About 50 to 75 parts of ore are mixed with 50 to 25 parts of pig iron, while the carbonaceous material runs from about one-sixth to one-tenth of the weight of ore. After adding sawdust and a temporary binder, such as molasses, silicate of soda or pitch, the mixture is pressed into the form of briquets, which are heated to a temperature below the fusing point of the mass, but above the fusing point of the cast or pig iron. The sawdust is oxidized and disappears, leaving the briquet porous. A portion of the oxide is reduced by the metalloids in the cast iron, which fuses and coats the particles of oxide, with the result that the particles of new iron stick together and the briquet becomes an adherent mass of great consistency and strength. A certain proportion of the carbonaceous material disappears and the rest of it remains in the briquet. The briquets are added to the open-hearth furnace either by being charged upon the hearth or being added to the bath. When the briquets are to serve as a substitute for part or all of the scrap commonly used in open-hearth practice, the proportion of carbon used is somewhat lowered, so that the briquets shall, upon being fused in the hearth, add thereto a quality of metal substantially equivalent to scrap.

Open-Hearth Process.—Henri Delporte, Fils (801,440, July 30, 1907) proposes to conduct the open-hearth process in two or more stages for facilitating the refining. The furnace first receives the ore and limestone or lime and is then charged with pig iron and scrap or with pig iron alone. During the process more refining materials are added if necessary. When the greater part of the impurities, particularly silicon, phosphorus and sulphur, have been removed, the partly-refined metal is withdrawn by being tapped into a ladle and the slags are run out of the furnace. Then the furnace is again charged with ore and limestone or lime and the liquid metal in the ladle is poured back into the furnace. In this second stage of the process, metal already higher refined, comes in contact with fresh refining material in a furnace free from slag, and the action of such material is rapid and thorough. "The impurities and particularly phosphorus are in this manner easily removed."

Pig Iron Production.—The local conditions of California, as characterized by abundance of oil and scarcity of coal, are reflected by a patent of S. McDonald (859,572, July 9, 1907). The iron oxide ore is first fused in a smelting furnace by means of oil or gas burners. The molten product is then carried to the top of a furnace, some 40 feet high, and filled with coke or solid carbon, which had been previously brought to incandescence (2,700° to 3,000° F.) by means of a temporary fire-blast. The molten ore in passing downwards through the pieces of incandescent coke or carbon is deoxidized. Besides the saving in coke, it is said to be an advantage of the process that by using a fire from fluid fuel for the preliminary fusing of the ore the introduction of sulphur into the product is largely avoided.

Welding Compounds.—A. J. Hanlon (865,887, Sept. 10, 1907) describes the following composition of a flux for welding cast iron and steel together or to other metals, such as silver, copper, etc. Six ounces of borax, 3 carbonate of soda, 3 glass, 3 oxide of iron and 1 ounce of rosin are pulverized and mixed dry. The metals to be welded are cleaned and heated, and the compound is sprinkled on them in the shape of powder while heating.

Agglomerating Fines.

Use of Silica and Lime.—W. Schumacher (864,804, Sept. 3, 1907) agglomerates ore fines, blast-furnace dust, etc., as follows: Silicious materials, such as sand, quartz or flint, are ground to an impalpable powder, the particles of which have the form of flakes, needles, etc., as distinguished from the approximately prismatic or globular shape which very fine sand has in nature. This impalpable silica powder is mixed with an approximately equal quantity of lime, and is added in the amount of about 5 per cent to the material to be agglomerated. The mass is formed into briquets, which are hardened by exposing them to the action of steam under pressure in a closed vessel. Calcium silicate is thereby formed which acts as a binder. Only a very small proportion of the silicious material (only from ⅛ per cent to ¼ per cent of the final product) remains uncombined.

Gold.

Cyanide Process.—In the treatment of gold and silver-bearing ore in which a large percentage of copper is present, some difficulty is found in the recovery of the precious metals, particularly of the silver, owing to the fact that the cyanide solu-

tion becomes heavily charged with copper. It takes up 40 per cent of its own weight in copper, and when the solution is once loaded with copper, no silver values can be obtained. I. Anderson (861,628, July 30, 1907) proposes the following treatment in successive steps. Pulp containing precious metals and copper is first treated with potassium cyanide the extracted metals are precipitated with sulphuric acid. The sulphuric acid is then neutralized with lime, whereby the cyanide solution is regenerated. The pulp is then again subjected to treatment with the regenerated solution, whereby the rest of the precious metal values is taken out. This solution now containing gold and silver is then used for the treatment of fresh pulp to take out the copper and so on as before.

Treatment of Refractory Ores.—According to a process of W. P. Wynne and J. H. Grant (862,229, Aug. 6, 1907) antimony-gold ores, pyrites and other refractory ores are powdered, and when in the form of a spray are subjected to the action of flat sheets of flame emitted from oil or gas burners which produce a temperature of 450° F. The antimony is thereby volatilized and driven off with other fumes and collected in the form of oxide of antimony in a surface condenser. The special feature of the process, however, is that the ore after passing through the flames is suddenly cooled, so that it does not sinter or fuse into a mass or clinkers, in which condition it would be unsuitable for further treatment and the extraction of gold would become impossible. For this purpose the hearths are hollow and are continuously supplied with a cooling fluid, so that the particles of ore falling on them are instantaneously cooled below the fusing point as they accumulate. They are then gradually moved forward by the rabbles from one hearth to the next.

Testing Ores in the Field.—L. M. Pritchard (861,535, July 30, 1907) proposes the following method of testing ores for gold, suitable for the use of prospectors in the field. It consists essentially in pulverizing the ore, treating it with iodine dissolved in an aqueous solution of potassium iodide to dissolve the gold, agitating the solution thus formed with mercury to form an amalgam with the gold, and separating the gold from the mercury, preferably by means of nitric acid. "Iodine mixed with potassium iodide can be easily carried by the prospector as a part of his outfit as dry salts, to which he can add water to make the solvent solution when he desires to use it."

Slime and Pulp Treatment.

Washing Process.—T. Griswold, Jr. (863,061, 863,062 and 863,168, Aug. 13, 1907) patents a process and apparatus for treating slimes or pulps, for which separation by settlement and decantation would be very slow and which are not adapted to filtration or leaching. The solvent or washing fluid is passed in one direction through a series of settling and mixing chambers, while the pulp or sludge is simultaneously passed through the same series in the opposite direction. The sludge is thereby repeatedly washed, settled and rewashed in solvent of progressively increasing solvent power and carrying a decreasing burden of "values," until when discharged at the end of the series the sludge is practically deprived of soluble values.

Copper.

Pyritic Smelting.—R. Baggaley (862,378, Aug. 6, 1907) patents the following process for treating copper sulphide, oxide or carbonate ore. The first step is a smelting operation, by which without carbonaceous fuel or with very little carbonaceous fuel and without previous calcining and water concentration, the ore is reduced to a matte containing about 40 per cent of copper. Into a converter, provided both with smelting tuyers and bessemerizing tuyers, a predetermined charge of sulphide ores is introduced, together with oxide and carbonates if desired, and with suitable fluxes, only about as much fuel being added as is necessary to ignite and thoroughly start the process. The charge is so selected and proportioned with reference to the contact of iron and sulphur as to convert the bases into silicates without the use of carbonaceous fuel. In this converter the ore is smelted by the smelting tuyers, and the matte, which sinks to the bottom after smelting, is enriched by the converting tuyers to a point where the resulting slag will not contain a greater proportion of copper and valuable metals. The matte should contain about 40 per cent of copper.

The second step of the process is the utilization of the molten slag for the development of heat in steam boilers, etc., and is then discharged at the dump pile. The third step consists in transferring the matte from the first step in molten state to a second converter, where it is enriched until practically all the bases to be separated are removed. The slag resulting from this operation and containing a considerable quantity of copper is returned in the fourth step to the ore bins.

The matte from the third step contains about 80 per cent of copper. It is treated again in the fifth step in a converter provided with converting tuyers and with a flue for the introduction of flame, which prevents the bath from chilling at the latter part of the blow. By the action of the blast the matte is enriched to the point at which practically all the sulphur, bismuth, antimony, selenium, tellurium, etc., are eliminated. For this purpose it is necessary to blow the charge to the point where a small amount of oxide or sub-oxide of copper is formed. At the end of the blow the floating impurities are skimmed off from the surface. In the sixth and last step of the process the converter is tilted and the molten copper is poured into another furnace, the flame in which is capable of regulation, where it is poled to remove the sub-oxide, or if desired, hydrocarbon gases may be injected below the surface of the copper, and suitable additions may be made to the metal.

Two other patents of the same inventor (864,719, Aug. 27, and 865,671, Sept. 10, 1907) refer to details of construction of the converters used in his process.

Nickel.

Mond Process.—The well-known Mond nickel process consists in heating oxide of nickel, or material containing the oxide, in a reducing gas at a temperature between 350° and 500° C., allowing the material to cool and subjecting it to the action of a stream of carbonic oxide gas whereby the nickel is volatilized in the form of nickel carbonyl. Carl Langer (865,969, Sept. 10, 1907) calls attention to the fact that it is essential to keep the temperature of the material between 40° and 50° C. at atmospheric pressure for the action of the carbonic oxide gas on nickel. Since this reaction evolves heat, artificial cooling must be resorted to, and an apparatus for this purpose is described in which the cooling fluid is passed through passages in the reaction apparatus, around or over which passages the material under treatment is moved.

Tungsten.

Chloridizing Process.—R. McKnight (862,987, Aug. 6, 1907) treats tungsten ores as follows. The ore is reduced to a fine consistency, about 30 mesh, and mixed with double the amount of common salt and brought into a heating furnace, its temperature being not over 750° C. By this treatment the tungsten in the ore is converted into a volatile and soluble chloride or double chloride of sodium and tungsten, according to the equation:

$$FeWO_4 + 2NaCl = WO_2Cl_2 + Na_2O + FeO$$

$$WO_3 + xNaCl = WO_2Cl_2 + Na_2O + (x-2)NaCl$$

The volatilized double chloride is condensed in a suitable condenser, while the residue, while hot from the furnace, is allowed to drop into water. It quickly disintegrates and crumbles, and that portion of the tungsten which has not volatilized passes into solution, from which its acid or the metal itself can be obtained in any suitable manner. It is

stated that vanadium, uranium, molybdenum and tellurium ores can be treated by analogous methods. In some cases the inventor prefers to precipitate the acid of the rare metal by rendering its solution acid by means of hydrochloride acid. If the latter is led into the solution in gaseous form, the sodium chloride is thrown down along with the acid of the rare metal. By washing the mixed chlorides with water, the sodium chloride is obtained in the filtrate and the rare metal acid as the residue on the filter. In cases where the ore contains a metal whose oxide is soluble in ammonia, such as silver, copper, nickel, zinc, etc., the inventor uses as the condensing liquid for the volatilized portion and as the solvent for the residual portion a solution containing ammonia.

Aluminium.

Alloy.—F. W. Fletcher (867,194, Sept. 24, 1907) patents an alloy for shoes of beasts of burden, consisting of 30 pounds aluminium, 1 pound gunmetal and 1/4 pound white metal. The gunmetal is formed of 90 parts of copper and 10 parts of tin, while the white metal consists of a mixture of 6 parts of tin with 1 part of copper admixed with a mixture of 6 parts tin and 1 part of antimony.

Metal Cutting with a Burner.

Cutting Metal Articles.—With respect to the method of cutting metal plates, etc., with the blow-pipe, as described in the article of Mr. M. U. Schoop (page 308 of our August issue), two recent patents are interesting. One granted to Messrs. F. Jottrand and P. Sluys (859,604, July 9, 1907) is assigned to the Société Anonyme L'Oxhydrique Internationale, which company had an interesting exhibit of such apparatus at the exhibition in Liége two years ago. The principle is to heat with the oxy-hydrogen flame the plate to be cut along the line of section and simultaneously direct upon this line of section a jet of oxygen under pressure. The metal is raised to such a temperature that oxidation along the line of section takes place rapidly; the metal itself does not melt but the oxides which have a lower melting point flow readily, and the cutting line as sharp and clean as if the metal had been sawed. The present patent relates to the cutting of circular curves of any desired radius, and for this purpose the blow-pipe with the accessory oxygen tube is made one leg of compasses, so that by drawing a circle the plate is cut. A second patent granted to F. Jottrand (866,866, Sept. 24, 1907) relates to the principle of the method. The first claim reads as follows: "In an article for cutting metallic articles, means for heating the article to be cut and means for simultaneously supplying oxygen under pressure to the heated portion of the article."

Industrial Liquid Air.

Atmospheric air is a mixture of about 23 per cent by weight of oxygen and 77 per cent by weight of nitrogen. To make the constituents of air available for industrial use two ways are open. One is to combine the nitrogen and the oxygen so as to form nitrogen oxide which can be worked up into nitric acid or nitrates. The second way is to separate the nitrogen from the oxygen in the air and make both constituent gases individually available for various applications. Both methods require extreme temperatures, the first method an extremely high temperature, such as is obtainable from the electric arc; the second an extremely low temperature, since the separation of air into its constituents depends on the liquefaction of the air and its subsequent fractional evaporation.

An extensive plant for producing oxygen from liquid air on an industrial scale is now being erected in Buffalo by the Linde Air Products Co., Dr. Linde's system of air liquefaction and subsequent rectification being applied. For the annexed illustration of the plant and the information given in the following notes, we are obliged to Mr. Cecil Lightfoot, the consulting engineer and general manager of the company.

The action of the Linde apparatus for producing liquid air is based on the refrigerating effect resulting from an expansion of air from a higher to a lower pressure and which is due to the performance of internal work. The action of any desired number of expansions is accumulated and intensified by causing each preceding expansion to act as a fore-cooler for the air for the following expansion. Since the refrigerating action depends upon the difference of pressure before and after expansion, while the work of compression corresponds to the ratio of these pressures, it is advantageous to select a large difference in pressures but a small ratio of pressures. In the Linde apparatus air is expanded from an initial pressure of about 200 atmospheres to about 50 or 20 atmospheres, so that the difference of the pressures varies between 150 and 180 and the ratio is between 4 and 10.

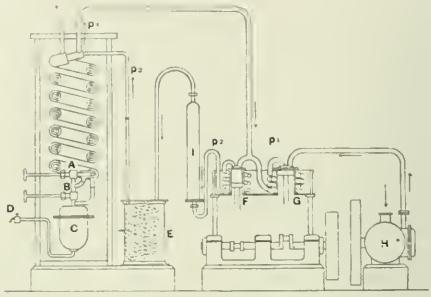


FIG. 1.—APPARATUS FOR MAKING LIQUID AIR.

As will be seen in Fig. 1 a triple coil is provided, which is composed of copper tubes placed one within the other. This is called the heat interchanger. Air compressed to 200 atmospheres flows downward through the innermost coil, at the lower extremity of which it is allowed to expand to an intermediate pressure of 20 to 50 atmospheres. The expanded air is then returned through the annular space between the innermost and middle coils to the top, when it is again compressed up to 200 atmospheres pressure and the cycle is repeated. Immediately behind the first regulating valve A is placed a second valve B, through which, when the operation of the machine has been brought to a state of equilibrium, a small quantity of air is allowed to escape at atmospheric pressure, a corresponding amount being introduced into the cycle from the surrounding atmosphere. Part of this air leaves the second regulating valve in the liquid state and collects in the vessel C; the remaining portion is returned to the atmosphere through the annular space between the middle and outer coils. The liquid air is drawn from the collector by means of the small cock D.

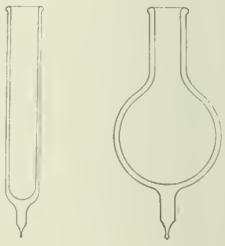


FIG. 2.—LIQUID AIR CONTAINERS.

In the larger installations the necessary compression of the air is effected by means of a high-pressure air pump, which is usually arranged for two-stage compression, working in conjunction with a single-cylinder low-pressure air pump. The high-pressure cylinder F of the former draws the partly expanded air from the heat interchanger at an intermediate pressure of about 50 atmospheres, and compressing it up to 200 atmospheres pressure, delivers it to the interchanger again through the cooler E. The air which is to be added to the

cycle as "make-up" is supplied by the low-pressure air pump H, which draws it from the atmosphere, compresses it to a pressure of 4 atmospheres and delivers it to the low-pressure cylinder G of the high pressure air pump, where it is compressed to a pressure of 50 atmospheres. At this pressure it enters the high-pressure cylinder, together with the partly expanded air from the heat interchanger, as described above.

Low-pressure compressors are not usually supplied with the smaller sizes of air-liquefying plants, the lower pressure of the cycle being in such cases maintained at 20 atmospheres and the low-pressure cylinder G drawing the "make up" air direct from the atmosphere.

FIG. 3.—WORKS OF THE LINDE AIR PRODUCTS CO.

Regulation of the several pressures is performed with the aid of pressure gauges by means of regulating valves in the heat interchanger. Safety valves are provided to prevent the maximum pressures being exceeded.

In electric-furnace operations when electric energy is expensive it is advantageous to preheat the charge or to start at once with a molten charge so as to produce only the highest temperatures from electrical energy, in order to save in the consumption of the expensive electrical energy. In the liquefaction of air where the object is to get a very low temperature it is advantageous in quite an analogous way to pre-cool the air. For this purpose a fore-cooler is provided by means of which the compressed air is reduced in temperature to 5° or 10° above zero Fahrenheit, by filling the receptacle provided for the purpose with a suitable freezing mixture, such as ice and salt. This is practical in smaller illustrations.

On the other hand with larger installations, the preliminary cooling of the air is preferably brought about by a small belt-driven refrigerating machine on the ammonia compression system. The adoption of fore-cooling is advisable in all cases, but especially when the cost of power is an item of great importance.

Between the compressor and the fore-cooler, apparatus is provided for separating water from the compressed air. This apparatus is provided with a suitable drain cock. Further extraction of the aqueous vapors from the compressed air with the smaller installations is performed by the fore-cooler. In larger plants the drying process is effected after the last stage of compression by means of chloride of calcium placed in the dryer supplied with the machine.

If the liquid air is to be used for the production of pure oxygen and pure nitrogen it is subjected to a process of rectification which is very similar to the process employed in spirit distilleries for the separation of alcohol and water. In this way it is possible to get oxygen 95 per cent pure, and if the output is reduced by 10 or 20 per cent the purity of the oxygen may be brought up to as much as 98 or 99 per cent. The chief advantages of this method of producing pure oxygen are claimed to be low expenses, simplicity and safety in work, and the freedom of the oxygen from water vapor, chlorine, etc. The residual gases entirely consist of the ordinary nitrogen constituents of the atmosphere.

An interesting application of nitrogen produced from air in this way is in the production of calcium cyanamide. Five Linde plants are already at work in Europe on a very extensive scale for this purpose alone, whilst other and still larger installations are now in course of construction, so that the industry appears to be already well established. It will be remembered that for the production of cyanamide, calcium carbide is treated in a nitrogen atmosphere at an elevated temperature. It is, therefore, necessary to first get the nitrogen from air. The question then comes up what to do with the oxygen, and while there are, of course, many applications like its use in blow-pipes, etc. the interesting suggestion has been made to use the oxygen for enriching atmospheric air in oxygen and then to treat the latter by electric arc discharges to produce nitrogen oxides for the subsequent manufacture of nitric acid and nitrates. In this way the two methods which have so far been found practical for the fixation of atmospheric nitrogen would work side by side; the nitrogen obtained from the liquid air would be used in the calcium cyanamide manufacture and the oxygen would be used in the nitric acid manufacture.

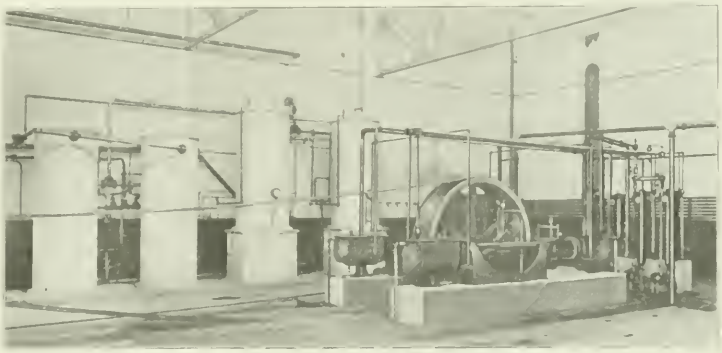


FIG. 4.—PART OF MAIN ENGINE ROOM SHOWING THE FOUR STAGE AIR COMPRESSOR, THE TWO FORE-COOLERS AND THE TWO INTERCHANGERS.

Altogether about 100 liquid air plants on Dr. Linde's system have already been supplied, of which nearly half are employed either for the production of oxygen or of nitrogen in the pure state, or of both.

Of course liquid air is useful for many other purposes, especially for all researches or processes in which extremely low temperatures are necessary, since liquid air forms perhaps the most convenient agent for the production and maintenance of such temperatures. Liquid air is also used in surgery, particularly in treatment of certain affections of the skin.

Liquid air boils at atmospheric pressure at 312° F. As the more volatile nitrogen evaporates the color of the liquid assumes a bluish tinge, the color of liquid oxygen. In the liquid state, air occupies 1/800 of the space occupied by the same weight of air in the gaseous form at normal temperature and atmospheric pressure.

Vacuum vessels are necessary for the storage of liquid air, oxygen and other gases which only liquefy at low temperatures. Such vessels are generally constructed either cylindrical or globular in shape. As shown in Fig. 2 they consist of two glass vessels, one enclosed inside the other and united at the neck. The space between the two vessels is thoroughly exhausted and sealed under a high permanent vacuum. Liquid stored in a vacuum vessel of this construction is very perfectly insulated from the effect of external heat and evaporates slowly.

Approximately the rate of evaporation of liquid air in vacuum vessels of this construction is from 5 per cent to 15 per cent of the original volume per 24 hours, according to the size of the vessel. As evaporation only takes place from the surface of the liquid it is obvious that the size of the vessel is an important factor in determining the length of time for which liquid air can be stored. It should also be noted that if allowed to rest in a quiescent state evaporation progresses much less rapidly than if the vessel containing the liquid air is subject to vibration.

Vacuum vessels of 2 litres capacity and upwards should not be tilted in order to pour out liquid because of the severe strain thus thrown on the glass at the neck of the vessel on account of the contraction which takes place. This is due to the sudden cooling of the glass at the neck when the liquid comes into contact with it. A small hand-pump is a convenient device for emptying vessels without tilting or inverting them.

Electric Muffle Furnace.

The Hoskins Co., of Chicago, who succeeded William Hoskins & Co. in 1905, have commenced the manufacture of the Hoskins electric furnace in addition to the well-known line of Hoskins hydro-carbon blow-pipes and furnaces, which have been on the market since 1880. In this new electric furnace (see also the patent of March on page 413) a great reduction in the cost has been made possible by the use of a patented resistance wire that will not burn or melt at 1,000° C., and which oxidizes only a very little at this temperature, as a matter of fact, has a melting point above 1,400° C.

ELECTRIC MUFFLE FURNACE.

It is a well-known fact that nothing except platinum has heretofore been used for furnace work, and on account of the excessive cost only furnaces of very small capacity have been made. This wire has six times more electrical resistance than platinum wire, and owing to this greater resistance they are enabled to make a furnace without any rheostat or controlling device.

All the resistance wire being wound on the furnace the heat is developed in the furnace chamber, doing useful work instead of part of it being used in heating the air surrounding the rheostat as is usual in platinum wire furnaces. These furnaces can be operated on the ordinary 110-volt electric light circuit, either alternating or direct, for the smaller laboratory sizes.

The same company is also about to put on the market a special electric resistance furnace for alternating current only, that will melt anything from lead to platinum.

These new furnaces will be applicable to every variety of melting and heating work, and at the low price at which they are sold should fill a demand for an electric resistance furnace large enough for all commercial melting operations up to 100 pounds capacity. We also understand the company is prepared to produce electric heating devices of any kind.

Electric Annealing and Hardening Furnace.

On pages 305 and 514 of our Vol. IV. we noticed an electric furnace for annealing and hardening tool steel. Its construction is of great simplicity. Two iron plates at the opposite ends of a vessel filled with a fused salt (barium chloride being mostly used) are connected to an alternating-current transformer. The Joulean effect of the current keeps the bath molten, and by regulation of the current it is easy to adjust the temperature very exactly and quickly. The tools to be hardened are placed within the fused salt. A furnace of this type, which is controlled jointly by the Allgemeine Elektricitats Gesellschaft, of Berlin, and by the General Electric Co., of this country, was shown in Mr. C. J. Russell's electric furnace exhibit at the last Philadelphia meeting of the American Electrochemical Society, as noticed on page 233 of our June issue.

In an experimental lecture recently held by Mr. L. M. Cohn before the Vienna Electrical Society, some interesting figures as to cost were given. Comparative tests were made on the cost of hardening milling cutters in a gas furnace of American make and in an electric furnace of the above type. In the gas furnace several cutters could be hardened at the same time, while the electric furnace, which was available, was of such a size that only one cutter could be placed in it. Nevertheless, the hardening of 100 cutters required 50 hours in the gas furnace and only 10 hours in the electric furnace. This is simply due to the fact that the temperature in the electric furnace can be adjusted quickly and easily and is always under absolute control.

The cutters were preheated to about 400° and then heated to 1,150° C. and then cooled. The total cost for the gas furnace was

350 cubic meters of gas	$10.81
Power for blowing	1.25
Wages for 50 hours at 17.5 cents	8.75
Total	$20.81

The total cost for the electric furnace was

200-kw. hours at 2.5 cents	$5.00
Coke for preheating	.25
Wages for 10 hours at 17.5 cents	1.75
Fresh barium chloride filled in	.14
Total	$7.14

This shows that under European conditions the electric furnace was very considerably cheaper than the gas furnace. It is true the price charged for gas in this comparison is somewhat high and the price of electrical energy is somewhat low. But the decisive element—which would be even of much greater importance in this country—is the saving in time and the corresponding saving in wages.

Alloys for Steel Manufacture.

Several new alloys for steel works and foundries have been placed on the market by the firm of Hermann & Essing in Cologne, Germany. One is a high-percentage ferro manganese, refined so as to be low in carbon. Its average analysis is 88 to 92 per cent Mn, 4 to 6 per cent Fe, 1.5 to 2.5 per cent C.

Another new alloy is refined silico manganese, which is stated to have the advantages of great purity and high efficiency with low weight, and its reducing power is said to be about three times that of ferro-manganese. The average analysis of this alloy is 68 to 70 per cent Mn, 27 to 30 per cent Si, 2 to 3 per cent Fe, 0.1 to 0.2 per cent C and traces of phosphorus and silver. This alloy is specially suitable for steel refining. It represents an energetic reducing agent. If used in moderate quantities, that is, in proportions corresponding to the degree of oxidation of the bath, the alloy will be almost completely oxidized, forming a manganese silicate, which floats on the surface of the bath. Should any unoxidized manganese or silicon remain in the bath this could be only in very small quantities, which would not be deleterious.

Under these conditions this alloy is suitable for producing a very homogeneous very-low-carbon steel containing very little manganese, free from pipes and blow-holes that is, soft and very soft sorts of steel, including the manufacture of castings free from blow-holes. By proper addition of carbon to this steel, which contains only a small amount of manganese, hard and very hard steels rich in carbon may be made, and their quality will be much superior to steel containing greater quantities of manganese.

Ferro-aluminium is a very useful alloy for steel and iron foundries, since the aluminium removes all impurities which are deleterious to the quality of iron and steel. The melting point is lowered by an addition of aluminium. The high temperature which is required to melt wrought iron makes it impossible to get solid strong castings. An addition of about 3 per cent ferro-aluminium overcomes this disadvantage, since the melting point is thereby lowered so much that overheating of the wrought iron cannot take place. The tensile strength of the iron is also increased by the addition of ferro-aluminium. The high fluidity of iron treated by this method permits a quick and easy escape of the gases, so that a dense homogeneous casting is obtained. An addition of 0.3 to 5 per cent of a 10 per cent ferro-aluminium is generally used.

Notes.

American Electrochemical Society.—At the meeting of the Board of Directors, held in Philadelphia on July 31 the following gentlemen were elected members of the Society: Franz Roessler, manufacturing chemist, Perth Amboy, N. J.; Eugene Haanel, Ph. D., director of mines, Department of Mines, Ottawa, Can.; L. D. Vorce, superintendent Pennsylvania Salt Manufacturing Co., Wyandotte, Mich.; Herschel C. Parker, professor of physics, Columbia University, New York City; John W. Brown, Ph. D. director research and battery laboratory, National Carbon Co., Cleveland, Ohio; John G. Kremers, electrical engineer and chemist, the Wisconsin Sugar Co., Menomonee Falls, Wis. At the meeting of the Board, held in New York City on Aug. 31, the following gentlemen were elected members: Remo Catani, electrical engineer, Société Elba, Portoferraio, Elba, Italy; William Acheson Smith, vice-president, International Acheson Graphite Co., Niagara Falls, N. Y.; Albert E. Greene, electrochemist Noble Electric Steel Co., Heroult on the Pit, Baird, Shasta County, Cal.; Hy. L. Kohler, chemist, Scullen Gun Iron & Steel Co., St. Louis, Mo.; Horace M. Engle technical director, the Southern Exploration Co., Terry Building, Roanoke, Va.; Louis Liebmann, Ph. D., electric furnace engineer, Frankfort-on-the-Main, Germany.

Society of Chemical Industry. The season of the New York Section of the Society of Chemical Industry will be opened by a meeting on Oct. 25, and meetings will be continued monthly, on the third Friday after the first Monday of every month. All the meetings will be held in the Chemists' Club, and will be preceded, as usual, by an informal dinner.

American Peat Association.—A meeting has been called, to be held on Oct. 23 to 26, at the Jamestown Exposition, to consider an organization of those interested in the development of American peat and swamp lands. The United States Geological Survey has established a fuel testing plant at the Exposition, where peat and products brought together for examination and comparison will be on exhibition. A peat exhibit will also be made in the Mines and Metallurgy Building. The temporary secretary and treasurer of the proposed association is Mr. Julius Bordollo, Kingsbridge, New York City.

Electrometallurgy at Columbia.—The lectures in electrometallurgy at Columbia University have been somewhat extended, Dr. Edward F. Kern (who was formerly connected with Mr. Anson G. Betts) giving this course. A laboratory of electrometallurgy has also been established under Dr. Kern at the School of Mines. Besides the apparatus for electric smelting, refining and testing already owned, the following has been added: Six 144-amp. hour "Bijur high-duty" storage cells, switchboard for connecting these in any desired combination to give current of 10 to 100 amps. at 2 to 12 volts, four Weston standard ammeters for 5 to 50 amps. capacity, and two voltmeters of varying delicacy, rheostats, etc. Current up to 500 amps. at 220 volts can be drawn from the university power circuit. To the metallographic laboratories have been added one Chatelier and six Leitz microscopes for examination and photo-micrography, desk galvanometers and couples for pyrometry, a Wanner and a Féry optical pyrometer, a recording thermoelectric pyrometer, standard thermocouples for checking and calibrating pyrometers, Sauveur specimen cabinet, polishing and emery wheels, etc. Two complete experimental cyanide plants have been installed. Dr. Kern has investigated the electrolysis of metallic sulphides in fused electrolytes, the electrolytic refining of iron, the electrolytic treatment of lead zinc ores for the recovery of their metallic content and the production of copper vanadium alloys.

Standard Symbols for Wiring Plans.—The September issue of *The National Electrical Contractor* contains the revised set of standard symbols for wiring plans, as adopted and recommended by the National Electrical Contractors Association of the United States and the American Institute of Architects.

Technical Publicity Association.—At the first meeting of this season, Messrs. N. W. Gage and B. Phillips spoke on the subject of mailing lists.

Tube Mills.—Mr. Max F. Abbé, president of the Abbé Engineering Co., New York, has just returned from a five months' trip in Europe. He visited England, Belgium, Germany and France. In several of the countries he made contracts for the manufacture of his tube mills and linings under various patents that he owns. In Germany he made a contract with the Fried. Krupp Aktiengesellschaft Grusonwerk at Magdeburg-Buckau for the building in the United States of their celebrated Excelsior Mills, of which the Krupp people have sold 30,000 in various parts of the world. The Abbé Engineering Co. will be ready within a month to supply the trade with mills of this type.

Assayers' Supplies.—We have received from the Denver Fire Clay Co., of Denver, Col., their illustrated 1907 catalog of assayers' and chemists' supplies. It is a volume of 350 pages, covering the following two departments: Chemists' and assayers' laboratory supplies, special electrical apparatus for analytical work, outfits for assayers and prospectors, school sets of chemical apparatus, collections of minerals, models, etc., fire-brick, tile and fire clay material, chemicals and reagents.

Alternator Construction.—A motion for preliminary injunction was brought in the United States Circuit Court for the Middle District of Tennessee by the General Electric Co. against the city of Nashville, Tenn., to restrain the city from the further use of some alternating-current generators manufactured by the Bullock Electric Manufacturing Co., on account of the construction of the laminated pole pieces attached to the revolving field spider. Judge Clark has issued the injunction but allowed the city of Nashville sixty days in which to change the pole pieces or to withdraw the machines from use entirely.

Steam Specialties.—The increasing demand for Powell steam engineering specialties makes an enlargement of the plant of the William Powell Co. a necessity. Plans are being prepared to erect buildings on ground, 37 x 200 feet, recently acquired by them and to increase their power plant by 200 hp.

Mr. Henry M. Huxley has resigned from the manager's staff of the Worcester district of the American Steel & Wire Co., to become assistant general manager of the Duplex Metals Co., manufacturers of Monnot copper-clad wire and sheets. Mr. Huxley will be located at 208 Fifth Avenue, New York.

Clay Products in 1906.—The United States Geological Survey has just issued a statistical table of the different clay products of the United States in 1906. The figures are given for common brick, vitrified paving brick or block, front brick, etc. The production of fire-brick amounted to 770,839,000, valued at $14,206,868 (against 679,071,000, valued at $12,735,404 in 1905). The value of the total brick and tile produced in 1906 is given as $129,591,838, the total value of pottery as $31,440,884, the sum of both being $161,032,722.

Brass and Iron Specialties.—One of the most complete and modern lines of brass and iron specialties for engine and boiler rooms, etc., is shown in the catalog of the William Powell Co., of Cincinnati, which has recently been issued. This catalog presents their line in a most complete and practical manner, giving dimensions of every article for which a dimension may be required, and explaining in detail the merits of their well-known specialties. A valuable series of tables and rules is bound in with the catalog, giving in a concise form information that every engineer and shop manager requires in his daily practice. A copy may be had for the asking.

Wet Process for Gold, Silver and Copper Ores.—Bulletin No. 4 of the Hendryx Electro Cyanide Co. describes first the Hendryx process for treating gold and silver ores. The special features are the following apparatus designed by Mr. Hendryx: The agitator in which the gold and silver from the ore pulp are dissolved in a cyanide solution; the decanting filter where the solutions are recovered and the tailings washed, and the zinc-dust precipitator. These apparatus are described and illustrated. For treating oxides and carbonates of copper, the copper is leached out in the agitator by means of sulphuric acid, and the copper is recovered in a special precipitator as cement copper, being precipitated by means of scrap iron. For treating copper sulphide ores the Hendryx process is as follows: The ore is ground and introduced into the agitator and sulphuric acid added. In this case the agitator is provided with insoluble electrodes. When the current is turned on the iron in the ore (which is nearly always naturally associated in sufficient quantity with the copper sulphide ores) is converted into ferric salt, which dissolves the copper. The copper is deposited on the cathodes, the iron is oxidized and regenerated as ferric salt (as in the old Siemens-Halske process). The solutions are then passed through electrolytic precipitating boxes. Ores containing gold and silver and copper are given a double treatment, first removing the soluble salts of copper and then cyaniding the gold and silver.

Stamp Milling Machinery.—Catalog 6-C of the Colorado Iron Works Co., of Denver, Col., contains on 72 pages illustrated descriptions of the various apparatus used in the treatment of gold ores by stamp milling and amalgamation. As is usual with bulletins issued by this company the little book is more than a trade catalog and contains as introductory article a well-written and concise exposition of the fundamental principles of treating gold ores by plate amalgamation.

Copper and Silver-Lead Ores.—Catalog No. 6 of the Power & Mining Machinery Co., of Cudahy, Wis., contains brief illustrated descriptions of the various pieces of machinery, furnaces, etc., used in roasting, smelting and refining of copper and silver-lead ores. Twenty-six pages are devoted to descriptions of crushing machinery, 14 to roasting furnaces, 30 to smelting furnaces, 11 to converters, besides descriptions of accessory machinery and notes on copper and lead refining and the use of producer gas in the power plant.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

Calcium Carbide (*Continued.*)

No. 594,740, Nov. 30, 1897. Herman L. Hartenstein, of Bellaire, Ohio.

Calcines limestone mixed with coke by forcing air upward through it. The hot lime is discharged from the lower end of the calcining kiln into an electric furnace consisting of a chamber having several rows of superposed openings in its side walls. Four vertical electrodes are arranged at the sides of the smelting chamber, with lining sections between them. Finely pulverized coke is blown through a main by illuminating gas under high pressure, and thence through multi-perforated tuyeres arranged in the side wall openings into the interstices of the heated lime. Electric current passes between the electrodes and through the charge in the form of "an almost infinite number of arcs generating heat and rendering the mass highly incandescent." The pulverized coke forced into the lime acts as a more or less perfect conductor. The molten "carbureted limestone" is withdrawn through a tap hole at the base. The hot gases pass upward into the lime kiln. Two electric smelting chambers are provided, each mounted on wheels. These are employed alternately, to permit repairs.

No. 595,712, Dec. 21, 1897, James Ellicott Hewes, of Philadelphia, Pa.

An electric furnace of the pot type provided with means for reciprocating the depending electrode in order to stoke the charge into the arc or current path. It is alleged that the carbide produced under continuous stoking is largely amorphous, containing at most a few crystals; and that while such amorphous carbide is less pure than ordinary crystalline carbide, the gas yield per horsepower-hour is not inferior, as the stoking increases the output per unit of power. The specific furnace shown comprises a brick receptacle having a loose lining of lime and carbon and a metal hearth constituting one electrode. The other electrode depends centrally above the hearth, is adjustable as to position, and is in operation reciprocated by means of a cam or eccentric.

Nos. 596,704, 596,705, 596,740, Jan. 4, 1898, Herman L. Hartenstein, of Bellaire, Ohio.

Proposes to use blast furnace slag as a raw material for the production of carbides. A suitable slag for the purpose is stated to contain 50-55 per cent of lime, 25-28 per cent silica and 16-18 per cent alumina. The product is stated to be a mixture of the carbon compounds of calcium, silicon and aluminium. The slag is introduced molten into a special form of converter mounted on trunnions and provided with tuyeres and with carbon electrodes, and is then impregnated with a suitable proportion of finely divided carbonaceous material, as coke, introduced through the tuyeres by means of a current of reducing gas, it being alleged that the gas increases the temperature of the molten slag. After a uniform mixture is secured the electric current is passed between the electrodes to effect the conversion into carbide.

NEW BOOKS.

The Metallurgy of the Common Metals.—By Leonard S. Austin. 406 pages; illustrated with half tones, drawings and diagrams of machinery and the appliances used in modern metallurgical practice. Bound in cloth. Price, $4.00. San Francisco, Cal.: Mining and Scientific Press.

Blast Furnace Calculations and tables for furnace managers and engineers, containing rules and formulas for finding the dimensions and output capacity of any furnace, as well as the regular outfit of stoves, heating surface, volume of air, tuyere area, etc., per ton of iron per day of 24 hours.—By John L. Stevenson. 44 pages of reading matter, tables and diagrams, and 116 pages containing forms for recording results of operations. Bound in leather. Price, $2.00 net. New York: D. Van Nostrand Co.

The Fire Assay of Gold, Silver and Lead in Ores and Metallurgical Products.—By Leonard S. Austin. First edition. 88 pages; 42 illustrations. Bound in cloth. Price, $1.00. San Francisco, Cal.: Mining and Scientific Press.

Dredging for Gold in California.—By D'Arcy Weatherbe. First edition. 217 pages; 103 illustrations. Bound in cloth. Price, $4.00. San Francisco, Cal.: Mining and Scientific Press.

Textbook of Organic Chemistry.—By A. F. Holleman, Ph. D. Translated from the third Dutch edition by A. Jamieson Walker, Ph. D., assisted by Owen E. Mott, Ph. D., with the co-operation of the author. Second English edition, rewritten. 589 pages; 83 illustrations. Bound in cloth. Price, $2.50. New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

Organic Chemistry, including certain portions of physical chemistry; for medical, pharmaceutical and biological students; with practical exercises.—By H. D. Haskins, M. D., and J. J. R. MacLeod. 378 pages; illustrated. Bound in cloth. Price, $2.00 net. New York: John Wiley & Sons.

Laboratory Outline of General Chemistry.—By Alex. Smith. Third revised edition in collaboration with W. J. Hale. Illustrated. Bound in cloth. New York: Century Co.

A Textbook of Physiological Chemistry for Students and Practitioners of Medicine. Third revised edition.—By E. C. Simon. 490 pages. Bound in cloth. Price, $3.25. Philadelphia: Lea Brothers & Co.

Merck's 1907 Index. Third edition. An encyclopedia for the chemist, pharmacist and physician, stating the names and synonyms, source of origin, chemical nature and formulas, physical form, appearance and properties, melting and boiling points, solubilities, specific gravities and methods of testing, physiological effects, therapeutic uses, modes of administration and application, ordinary and maximum doses, incompatibles, antidotes, special cautions, hints on keeping and handling, etc., of the chemicals and drugs used in chemistry, medicine and the arts. 472 pages. Bound in cloth. New York: Merck & Co.

Practical Test Book of Chemistry. Including specific tests and tests for purity.—By Dabney J. Palmer, M. D. 200 pages. Bound in cloth. Price, $1.00 net. New York: John Wiley & Sons.

Laboratory Work in Electrical Engineering. (Preliminary grade.)—By J. Roberts, Jr. Illustrated by diagrams and tables. Price, $2.00 net. New York: Van Nostrand Co.

Treatise on Electric Law. Law governing all electric corporations.—By Jos. Asbury and Howard C. Joyce. Second edition in two volumes. Bound in cloth. Price, $12.75. New York City: Banks Law Publishing Co.

Mechanical Engineer's Reference Book. Third edition revised and enlarged.—By Harrison S. Soplee. Illustrated by drawings and tables. Limp leather binding. Price, $5.00; with thumb index, $5.50 net. Philadelphia: J. B. Lippincott Co.

Textbook of Mechanics. Vol. II., Kinematics and kinetics. By Adolphe L. Martin. 218 pages, illustrated. Bound in cloth. Price, $1.50 net. New York: John Wiley & Sons.

Shaft Sinking Under Difficult Conditions.—By J. Riemer. Translated from the German by C. R. Corning and Rob. Peele. 189 pages, illustrated. Bound in cloth. Price $3.00. New York: John Wiley & Sons.

Department of the Interior.—United States Geological Survey. Advance Chapters from Mineral resources during 1906.

The Production of Talc and Soapstone in 1906. By Arthur J. Collier. 7 pages.

The Production of Quartz (Flint) and Feldspar in 1906. By Edson S. Bastin. 22 pages.

The Production of Chromite or Chromic Iron Ore in 1906. By Arthur J. Collier. 4 pages.

The Production of Precious Stones in 1906. By Douglas B. Sterrett. 44 pages.

The Cement Industry in the United States in 1906. By Edwin C. Eckel (advances in cement technology) and L. L. Kimball (statistics).

BOOK REVIEWS.

The Mineral Industry During 1906.—Its Statistics, Technology and Trade. Vol. XV. Edited by Walter Renton Ingalls. 954 pages; illustrated. Bound in cloth. Price, $5.00. New York: Hill Publishing Co.

We have received Vol. XV. of the *Mineral Industry* the great annual of the mining, chemical and metallurgical industry founded by the late Richard P. Rothwell.

This book has become such a standard and is so representative of the progress of the great source of elemental wealth in this age of metal, that there is little left to the reviewer save praise for the enterprise and sagacity of the publisher and editor. It is a credit to the American publishing trade. We have the same line of distinguished experts, as Prof. James Douglass, of the Phelps-Dodge interests, on copper in Arizona; W. R. Ingalls, the editor on zinc; Prof. R. H. Richards, on ore dressing; Prof. J. W. Richards, on aluminium, and Prof. L. S. Austin, on progress of the metallurgy of copper. Prof. J. F. Kemp is represented with a review of the literature on ore deposits, in addition to articles by many other engineers, each noted for excellence in their respective specialties.

The electrochemical industry is represented by special articles by Mr. F. J. Tone, on carborundum and on silicon; Mr. L. Addicks, on the enlarged electrolytic copper plant of the United States Metals Refining Co., at Chrome, N. J.; Mr. A. J. Lotka, on synthetic nitrates, giving a short account of the "flaming-arc furnace" at Notodden, Norway. All things considered, the present volume falls little short of the standard set by the eminent founder.

* * * *

Dredging for Gold in California. By D'Arcy Weatherbe. 8vo. 217 pages, 103 illustrations. Price, $4.00. San Francisco: Mining and Scientific Press.

A very attractive monograph, the best we have seen on this important industry. Its value is heightened greatly by the excellent illustrations, most of them from photographs.

The introduction gives clear ideas of the general problems involved; this is followed by a detailed description of how dredging ground is prospected, then forty pages on the construction of the dredging machines, well illustrated and very complete; then twenty pages on the operation of a dredge, equally well done. The thirty pages on the metallurgy of dredging, describing the screens, tables, sluices and cleaning-up, are full of valuable information from a first-hand authority; they are excellently written and illustrated. Costs are exhaustively handled, and the horticultural question of reclaiming

RECENTLY PUBLISHED

12mo, Cloth 498 Pages Price, $2.50 Net

Van Nostrand's
CHEMICAL ANNUAL
A Hand-book of Useful Data
for Analytical, Manufacturing and Investigating
Chemists, and Chemical Students
Based on Biedermanns' "Chemiker Kalender"
EDITED BY
Prof. J. C. OLSEN, A. M., Ph. D.
Polytechnic Institute, Brooklyn
Formerly Fellow Johns-Hopkins University
Author of "Quantitative Chemical Analysis, by Gravimetric, Electrolytic, Volumetric and Gasometric Methods."
With the Co-operation of Eminent Chemists
FIRST YEAR OF ISSUE, 1907

The absence of a comprehensive reference book of numerical data of the Science, has induced the publishers to undertake the publication of this Annual, which it is their intention to issue, with new data added, annually.

8vo, Cloth 367 Pages Price, 3.00 Net

SOLUBILITIES
OF
Inorganic and Organic Substances
A Hand-book of the most
Reliable Quantitative Solubility Determinations
COMPILED BY
ATHERTON SEIDELL, Ph. D. (J.H.U.)
Bureau of Chemistry, U. S. Department of Agriculture

The principal features which have been emphasized in the preparation of this volume are as follows:

Completeness of Data
Uniformity of Expressing Results
Selection of Most Reliable Determinations
Arrangement of Material

8vo, Cloth, Illustrated, 298 pages Price, $3.00 Net

EXPERIMENTAL
Electrochemistry
Theoretically and Experimentally Treated
BY
N. MONROE HOPKINS, M. Sc., Ph. D.,
Assistant Professor of Chemistry in the George Washington University, Washington, D. C.
Profusely Illustrated with 130 New Drawings, Diagrams and Photographs, accompanied by a Bibliography.

D. VAN NOSTRAND COMPANY
Publishers and Booksellers
23 Murray and 27 Warren Sts., New York

the worked-over ground is gone into. It is satisfactory to know, from the æsthetical as well as from the economic standpoint, that eucalyptus grows rapidly on these dumps, or that the unsightly piles can be scraped level and covered with a foot of soil for about $250 per acre. Since an average profit of nearly $4,000 per acre is made from working these grounds, it seems quite reasonable that the State should step in and require that no agricultural land be sold, leased or used for dredging purposes without the purchaser, leaser or owner being obligated, by bond or otherwise, to restore the land to a level, soil-covered condition. Such action by the State would stop the wicked desolation of some of the garden spots of the earth now going on unchecked.

The book concludes with a half dozen contributions by others to special sides of the dredging question, completing a most acceptable and valuable addition to the metallurgy of gold.

* * * *

THE FIRE ASSAY OF GOLD, SILVER AND LEAD IN ORES AND METALLURGICAL PRODUCTS. By L. S. Austin, Professor of Metallurgy and Ore Dressing in the Michigan School of Mines. 8vo. 88 pages. Price, $1.00. San Francisco: The Mining and Scientific Press.

The aim of the author is to present a single system of assaying, adapted for assaying these ores and products in the Rocky Mountain States. This system is called "Austin's Fire Assay."

The directions for sampling are brief and clear. We do not relish the imputation contained in the caution that the assayer should be "especially" careful if he is sent a regularly ground sample to assay, since another assayer can assay a portion of the same sample "as a check on his work." Perhaps it is a failing of human nature to be more careful when you may be checked off by another; but in teaching a man how to work, should we not hold before him the ideal of "best work" without regard to any possibly checking off? Furnaces and tools, crucibles, scorifiers and balances are briefly described. In the description of fluxes and reagents we note nothing new. The general classification of ores is very brief and somewhat vague; we cannot agree, for instance, that blende and pyrite form an "oxidized basic ore," or that galena and pyrite have "a semi-metallic appearance."

The scorification assay and the chemical reactions proceeding in it are described excellently, likewise cupelling and parting. Under the latter item very neat advice is given, to the effect that if less than one-fourth of the alloy is dissolved, to melt up with pure silver and part again. This might have very properly been prefaced by the direction to melt up the alloy button with three times its weight of silver, in the first instance, if it shows any trace of yellow color. The crucible assay is one of the best written chapters in the book, the reactions being explained in detail and the chemical equations given. Roasting, assay of matte, of high-grade silver sulphide, of cyanide solutions, base bullion, precious bullion and blister copper are each very briefly treated, also the assay of a lead ore.

Altogether, with its brief but clear treatment of reliable methods, the book forms a satisfactory introduction to assaying in the limited field intended to be covered.

* * * *

OPEN-HEARTH STEEL CASTINGS. By W. M. Carr. 12mo. 118 pages; 19 illustrations. Price, $1.50. Cleveland, Ohio: Penton Publishing Co.

It is a very encouraging sign of progress in metallurgical literature when we begin to have monographs, such as this, on a small corner of the metallurgy of iron, written by a competent author who knows at first hand what he is talking about. One man, be he even a Ledebur, cannot be at once a scientific master and a practical man in all parts of the metallurgy of iron, and therefore such comprehensive works as

Ledebur's are always capable of being supplemented by practical monographs such as the one before us.

The style of the writing is brief crisp and pertinent. Nothing but the bare essentials of present American practice are given, but these are given so clearly and pointedly that no bright American reading the book can fail to take them in at the first reading. The information thus gained will be somewhat scanty and fragmentary, but will form a first class basis for further study of the subject in a broader way, because it is almost all right as far as it goes.

The chapter on "Materials Used" contains an immense amount of data concerning fuels, pig iron, scrap, refractories, molding materials and tools, for acid and basic practice, compressed into the fewest possible words. The thirteen pages on "Furnace Construction" is very good, many items from the author's experience being valuable information. The short chapter on fuels is not so good; it is impossible to do even brief justice to such a subject in the space taken. The ten pages on the "Manipulation of Acid Furnace Heats" is finely done, as also the similar chapter on basic heats. These twenty pages give a vivid picture of the primary essentials of open-hearth practice. The attempt to compress "Chemical Analyses and Physical Tests" into nine pages is unsatisfactory; it is so condensed that only the expert could digest and use the information it contains—particularly on the chemical side. The relation between composition and physical properties is clearly presented in thirteen pages, with the success of the earlier chapters. The study of blow-holes is very brief and rather indefinite; it should have been double as long, because of the great importance of this topic. The ten pages on "Heat Treatment" gives a satisfactory first idea of the subject; the microphotographs show up too poorly to be of any assistance. Four pages on the use of "Thermit" show that the writer has brought his book thoroughly up to date. The concluding chapter on "Costs" is greatly condensed and gives only elementary ideas on a small plant.

Altogether, in the space taken up there was never before compressed so much useful and accurate information on this subject—and put into such comprehensible and entertaining form.

* * * *

The Elements of Chemical Engineering. By J. Grossmann, M. A., Ph. D., F. I. C., Chemical Engineer and Consulting Chemist in Manchester. With a preface by Sir William Ramsay, K. C. B. F. R. S. 152 pages; 50 illustrations. Price, $1.50. London: Charles Griffin & Co., Ltd. Philadelphia: J. B. Lippincott Co.

In the preface by Sir William Ramsay it is said that "in Britain there is, for the most part, a gulf fixed between the technical and the scientific chemist." That a similar gulf exists to some extent in this country was claimed in a much discussed paper by Mr. J. B. F. Herreshoff before the New York Section of the American Chemical Society a few years ago. The object of Dr. Grossmann's book is to bridge this gulf, to aid a student in proceeding from the scale of laboratory to that of manufacturing operations.

"It may be laid down as a fundamental difference between theoretical and practical work that whilst the question of cost does not enter into theoretical work, it is the fundamental basis of all technical work." Hence the apparatus for carrying out a reaction in the laboratory and a process in the works will be very different. But—and this is the fundamental leading idea of Dr. Grossmann's whole book—the operations which are carried out on a large scale may be considered "as almost natural evolutions arising from the work with the laboratory apparatus."

In this sense "the beaker and its technical equivalents" are discussed in the first chapter, with a description of the methods used on a large scale for mixing liquids, dissolving solids, for heating and evaporating. The titles of the following chapters

Just Ready

Electro Analysis

By EDGAR F. SMITH, M.A., Ph.D., Sc.D.
Professor of Chemistry, University of Pennsylvania

Fourth Edition, very completely Revised and greatly Enlarged and Improved. With 42 Illustrations Octavo; 346 pages. Limp Leather. $2.50 *net.*

Synopsis of Contents

Introduction. Sources of Electric Current: *Magneto-Electric Machines, Dynamos, Thermophile, Storage Cells.* Reduction of the Current: *Rheostats, Resistance Frame.*—Measuring Currents: *Voltameter, Amperemeter, an Electro-Chemical Laboratory.*—Historical Sketch. Theoretical Considerations. Rapid Precipitation of Metals in the Electrolytic Way. Use of Mercury Cathode.—Determination of Metals. Separation of Metals. Additional Remarks on Metal Separations.—Determination of the Halogens in the Electrolytic Way. Determination of Nitric Acid in the Electrolytic Way.—Special Application of the Rotating Anode and Mercury Cathode in Analysis.—Oxidations by Means of the Electric Current. The Combustion of Organic Compounds.—Index.

Descriptive Circular sent free upon request

The Food and Drug Act, 1907

Books Purchased by the Federal Government for the Use of Inspectors

Autenrieth. "The Detection of Poisons and Strong Drugs"	$1.50
Heusler. "Chemistry of the Terpenes"	4.00
Leffmann and Beam. "Select Methods in Food Analysis," 2d Edition ..	2.50
Richter. "Organic Chemistry," 3d Edition, by E. F. Smith. Two Volumes	6.00
Sayre. "Organic Materia Medica and Therapeutics," 3d Edition	5.00
Thresh and Porter. "Preservatives in Food and Food Examination" ..	4.50
Allen. "Commercial Organic Analysis," 9 Volumes	34.50
United States Pharmacopœia, 8th Revision	2.50
Sutton. "Volumetric Analysis," 9th Ed'n	5.00
Greenish. "Microscopical Examination of Foods and Drugs"	3.50

Circulars of These Books Upon Application

P. BLAKISTON'S SON & CO.
Publishers of Books on Technology, Chemistry, Biology, Pharmacy, Medicine
1012 Walnut Street Philadelphia

PALMER—*Practical Test-Book of Chemistry.* Including Specific Tests and Tests for Purity. 12mo, x + 190 pages. Cloth, $1.00.

EXTRACT FROM PREFACE—"In collecting these Tests and arranging them alphabetically, an effort is made to supply physicians engaged in practice, and pharmacists, with a ready means and safe guide for testing any substance presented for examination. And as only practical information is aimed at, the methods employed are very simple and form a series of unpretentious experiments."

GOOCH-BROWNING—*Outlines of Qualitative Chemical Analysis.* Small 8vo, vi + 145 pages. Cloth, $1.25 net.

MORGAN—*The Elements of Physical Chemistry.* Third Edition, Revised and Enlarged. 12mo, xii + 510 pages, 21 figures. Cloth, $3.00.

MORGAN—*Physical Chemistry for Electrical Engineers.* 12mo, viii + 230 pages. $1.50 net.

JOHN WILEY & SONS
43 & 45 E. 19th St. New York City

Eleventh Edition

Metallurgy of Cast Iron

A complete exposition of the processes involved in its treatment, chemically and physically, from the blast furnace through the foundry to the testing machine, being a practical compilation of original research.

By THOMAS D. WEST

Contents

PART I.—Manufacture and Use of Coke—Properties in Ores—Operations of Blast Furnaces—The Different Brands of Pig-Iron and How to Purchase and Use Them Intelligently (27 chapters). II.—Elements in Cast-Iron and Their Physical Effect—Utility of Chemical Analyses and How to Use Them in Making the Different Mixtures of Irons Used in Making Gray and Chilled Castings (21 chapters). III.—Properties of and Methods for Testing Molten Iron—Phenomena in the Actions of Cooling Metal, etc.—Results of Tests in All Kinds of Irons—Best Methods for Testing (23 chapters). APPENDIX. Selected Tables for Use in Furnace and Foundry Work.

Cloth 638 Pages 153 Illustrations Price, $3.00 net

Sent Anywhere, postpaid, for the Price by the

McGRAW PUBLISHING COMPANY

239 West 39th Street :: New York

ture. 2. Distilling flasks, Liebig condenser, fractionating tubes and their technical equivalents. 3. The air bath and its technical equivalents (with a description of conveying machinery and drying apparatus). 4. The blow-pipe and the crucible and their technical equivalents (open and blind roasters, regenerative furnaces). 5. The steam boiler and other sources of power (this chapter seems too short and condensed to be of much use). 6. General remarks on the application of heat in chemical engineering (use of steam and saturated steam, law of radiation losses, heat value of coal, steam boilers). 7. The funnel and its technical equivalents (filter presses, centrifugal apparatus). 8. The mortar and its technical equivalents (breaking and crushing machinery, stamp mills, mixing and grinding machines—though ball mills and tube mills do not find the consideration which they deserve). 9. Measuring instruments and their technical equivalents (weighing, density and areometer scales, temperature measurements, CO_2 recorders, etc.). 10. Materials used in chemical engineering and their mode of application (an excellent chapter dealing with brick-work, uses of different kinds of iron, of lead, copper, earthenware, etc.). 11. Technical research and the designing of plant (this chapter contains suggestions on technical research work in universities, notes on pure and commercial substances and suggestions on the way of proceeding in technical research with instructive numerical examples). A list of current prices of the principal chemicals and materials is added.

It is self evident that in the brief space of 152 pages the treatment of all these different subjects cannot be in any way exhaustive. By reading and digesting the book a student of chemistry will not become a chemical engineer. He can become an engineer only by doing practical engineering work. All a book can do is to lead a student's mind in a certain direction—to teach him to think not merely in equivalents, but in dollars and cents, and not merely in grams and milligrams but in tons. It seems to us that in this respect Dr. Grossman's book is eminently successful.

The book is highly suggestive and often gives good advice. Thus, to give only one example, "it may be safely stated that although every one has had ample opportunity of watching brick-setters at their work, few will have exercised their powers of observation sufficiently to know exactly how the work should be and is done." A chemical engineer who is called upon to design a plant should know this; he should also have a general knowledge of the principles of iron founding, the coupling of pipes, carpentering, joinering, etc. It seems to us that this little book should be very useful.

* * * *

MERCK'S 1907 INDEX. Third Edition. An Encyclopedia for the Chemist, Pharmacist and Physician, of the Chemicals and Drugs used in Chemistry, Medicine and the Arts. 472 pages. New York: Merck & Co.

The former editions of *Merck's Index* have become so popular that it is unnecessary to say anything about the general scope and character of the book. The new edition has been brought up to date by adding the newest products, by adopting the latest nomenclature, by consulting the most modern authorities, and, for the Merck products, by verifying the data in their laboratories and works. The Merck products are now indicated by the word Merck after the product.

Furthermore, the crude drugs of commerce have been added, and under each drug the dose of its extracts, tinctures, fluid extract etc., are given, instead of grouping all extracts, tinctures, etc., together as in the previous editions. No prices are given but comparative values; this is done very cleverly.

The book, which has become indispensable to many chemists, pharmacists and physicians in the past, will undoubtedly gain many new friends. It is sent to users of chemicals and drugs by the authors and publishers for remitting the forwarding charges, which amount to 25 cents in round figures.

Electrochemical and Metallurgical Industry

VOL. V. NEW YORK, NOVEMBER, 1907. No. 11.

Electrochemical and Metallurgical Industry

With which is Incorporated Iron and Steel Magazine

Published on the first of each month by the
ELECTROCHEMICAL PUBLISHING COMPANY,
[*Incorporated.*]
239 WEST 39TH STREET, NEW YORK.

J. W. RICHARDS, PH. D.....*President*
E. F. ROEBER, PH. D.....*Editor and Secretary*
C. E. WHITTLESEY.....*Treasurer*

Subscription Price: $2 per year, postpaid to any part of the world. Single copies 25 cents.

Copyrighted, 1907, by the Electrochemical Publishing Co.

Entered as Second-Class Matter, June, 1906, at the Post-Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, NOVEMBER, 1907.

CONTENTS.

EDITORIAL 435
New York Meeting American Electrochemical Society.... 435
Practical Applications of Colloids..... 436
The New Levels in the Price of Metals..... 436
Manual Training Again..... 437
The Iron and Steel Market..... 438
Application of the Laws of Physical Chemistry in the Metallurgy of Iron. By H. von Jüptner—I..... 438
Cost of Water Power..... 440
CORRESPONDENCE:
A Metallurgical Revival. By Walter E. Koch..... 440
Gas Analysis. By Herbert Philipp..... 440
Carbons for Electrometallurgy. By Francis A. J. FitzGerald.. 440
Report of the New York Meeting of the American Electrochemical Society, with Abstracts of Papers read by H. Noel Potter, A. Bliss Albro, William Roy Mott, A. E. Greene and F. S. MacGregor, Jos. W. Richards, Gustave Gin, Charles E. Baker, Harrison E. Patten, E. E. Free, Oliver P. Watts, S. A. Tucker, F. A. J. FitzGerald, L. H. Duschak and G. A. Hulett, Henry S. Carhart and F. J. Mellencamp, Herman Schlundt, A. G. Acheson, George F. Kunz..... 441
The Lash Steel Process. From the FitzGerald & Bennie Laboratories 455
Oxygen in the Arts. By Cecil Lightfoot..... 456
German Bunsen Society 456
Metallurgical Calculations. By J. W. Richards 458
NOTES ON ELECTROCHEMISTRY AND METALLURGY IN GREAT BRITAIN . 462
SYNOPSIS OF PERIODICAL LITERATURE..... 463
ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS..... 469
RECENT METALLURGICAL PATENTS..... 472
Free Engineering Library 473
Acid-Proof Brick and Tile..... 473
Concentrating Magnetite Iron Ore at Lyon Mountain, N. Y. 473
Modern Copper Converters Hydraulically Operated. By G. B. Shipley 474
Agitating Sulphur Burner..... 475
Low Temperature Measurements..... 476
New Laboratory Electric Furnace and Pyrometer Outfit 477
NOTES 479
DIGEST OF UNITED STATES PATENTS (Calcium Carbide). 480
NEW BOOKS..... 481
BOOK REVIEWS:
Edgar F. Smith, on Electro-Analysis 481
Max Schloetter, on Bromine and Iodine 482
Walter Löb, on Electrochemistry of Organic Compounds 482
Census for 1905 (Copper, Lead, Zinc)..... 483
Transactions of the American Electrochemical Society 484

New York Meeting of the American Electrochemical Society

The splendid success attained at the New York meeting of the American Electrochemical Society last month—as big a success as that of the delightful Philadelphia meeting in the spring—was due to careful planning and arranging a long time in advance. This double success should definitely settle any doubts which may still have been entertained (mostly by outsiders) whether the society is strong enough to stand on its own feet, and perhaps also the other doubt, which has occasionally found expression, whether two meetings a year is not one too many. It is a great pity that it is an impossibility to give an adequate account of the success of the meeting in its social features, in promoting professional solidarity by social intercourse of the members at the various social functions—on the highly enjoyed visit paid to Mr. Edison, to the man and his work, on the exceedingly interesting excursion to the De Lamar copper refinery, and at the charming banquet in Liederkranz Hall. While this success would have been impossible without the good feeling and the esprit de corps which have always been characteristic of the society, yet it is but fair to state that although the whole New York section was interested in planning, arranging, advertising and carrying out, yet by far most of the work was done by, and great credit is due to, Mr. Alois von Isakovics, the secretary of the section. The Chemists' Club and Columbia University were the gracious hosts of the society at the meetings, while the Chemists' Club also entertained the society at one of its enjoyable Smokers. Truly, the Chemists' Club of New York is rapidly becoming the recognized common social home of all the chemists and chemical engineers of this country.

* * *

In an equally effective way an excellent program of papers and lectures had been arranged for the professional sessions, and for this arrangement the thanks of the society are due to its president and secretary, Professors C. F. Burgess and J. W. Richards, and to the efficient Committee on Papers. A full account of the papers presented will be found in this issue. There was so much of interest and value that to go into details would be ungraceful towards those which could not be mentioned here on account of lack of space. But we must notice at least the three very able papers of Dr. Henry Noel Potter, giving the first, yet full, account of the foundation of a new electrochemical industry, that of silicon monoxide. The whole American electrochemical fraternity may be proud of Dr. Potter's work, not solely of the surprising industrial results, but of the scientific researches which form the foundation. Where there is so much to praise a critical remark cannot be suppressed, especially as the criticism we must make is an old one. The program of papers was far too full to permit adequate discussion. We do not see any other possible remedy but to have all papers printed in advance, and then let the society adopt such a rule as now ex-

sts at the meetings of the Iron and Steel Institute, that the meeting shall be devoted solely to discussion, the author of a paper opening the discussion and being limited to ten minutes.

Practical Applications of Colloids.

The colloidal state has been a subject of extended researches in recent years, but has mostly attracted the attention of scientists. The general engineering public has considered the matter as barren of practical results, although this idea is entirely wrong. The colloidal state now begins to make itself felt in a great many different fields. Dr. Whitney, in a lecture before the American Electrochemical Society two years ago, showed an instructive application to the dyeing of textile fabrics. Ferric chloride and potassium ferro-cyanide solutions produce Prussian blue on mixing, and this is a colloid whose precipitation may be prevented by removal of the electrolytes which are formed by the reaction, if the solution is not too strong. This removal may be easily brought about by dialysis. This colloidal Prussian blue will not dye or color a mass of agar jelly suspended in it, nor will it dye cotton—because, as a colloid, it exerts no osmotic pressure and therefore has no tendency to diffuse. It has no tendency to penetrate the jelly or the cotton. But just for the same reason, if in any way the colloid is produced within the jelly or the cotton, it will be impossible to wash it out. Dr. Whitney demonstrated this in the case of jelly by a sample which was treated first with ferric chloride, and after rinsing with potassium ferro cyanide solution. The resulting colloidal dye cannot be washed out from the jelly. This exceedingly pretty experiment shows clearly possibilities in unexpected directions. Last year colloids were much spoken of in connection with an entirely different subject, playing an important part in the publications of Dr. Kuzel on his electric tungsten lamp. While other tungsten filaments are made by the "paste" process and by precipitation on carbon cores, Dr. Kuzel claims to make use of tungsten in the colloidal state. How far this is the case in the industrial manufacture of his lamp is not known.

* * *

Mr. Edward G. Acheson's very interesting lecture on "deflocculated graphite," which will be found elsewhere in this issue, deals with an application of the colloidal state to lubrication, and apparently an exceedingly useful and promising application. The peculiar method of bringing the graphite into the colloidal or "deflocculated" condition should deserve further attention. It would appear to involve a new principle. Though the rationale of the method of forming the colloid is not clear, the invention is a fact, and everybody will congratulate Mr. Acheson upon the success of his never-tiring efforts to carry the triumphs of electrochemistry into new fields. While in this case the production of the colloidal state is the interesting feature, we are reminded of the reverse reaction—the precipitation of a colloid by addition of an opposite colloid or of an electrolyte—in reading Prof. Lorenz' paper on electrolysis of fused salts, an abstract of which will be found in the Synopsis in our present issue. Experimenters have long known that certain additions to the fused bath are useful in increasing the ampere-hour efficiency of operation. Prof. Lorenz shows that their effect is essentially to precipitate any mist or "schliere" which tends to pass from the molten cathode into the bath, with the result that when this mist reaches the anode the useful work of electrolysis is being undone. The metallic mist behaves just as though it was a colloid, and its precipitation takes place apparently just like the precipitation of a colloid. However, this matter also deserves further investigation.

* * *

To pass over again to an entirely different field, it has long been known that a purely chemical theory of the setting of cement must be necessarily unsatisfactory, since it cannot cover all phenomena which are involved. The setting of cement should be regarded rather from the standpoint of physical chemistry. It has also been known that colloids play an important part in the setting of cement. In this respect a contribution by Mr. R. H. Gaines to the discussion of a recent paper by Mr. Wm. B. Fuller, on the laws of proportioning concrete, before the American Society of Civil Engineers, is quite suggestive. Mr. Gaines is chemist of the New York Board of Water Supply, and this Board is carrying on an extended research on the waterproofing of cement. If we leave out all hypothetical refinements of Mr. Gaines' elaborate theory, his argument is simply that since colloids play an important part in the setting of cement, and since the addition of an electrolyte has a decisive effect on colloidal precipitation, it would be worth while to make experiments in which different quantities of a suitable electrolyte are added to the water in the cement. These experiments have been made by Mr. Gaines. The electrolyte chosen was ordinary alum, dilute solutions of which were used to replace the mixing water. The very interesting result is, that by replacing the mixing water with a 1 per cent solution of alum, watertight concrete is obtained of increased mechanical strength, as shown by compression and tensile strength tests. All these different examples show conclusively that the study of colloids is a subject of greatest importance even for the "purely practical man."

The New Levels in the Price of Metals.

If anything is under mechanical strain, there is sure to be fluctuations when the strain is great enough to effect a movement. The first displacement is quick and sudden, and then there are a series of smaller displacements, depending on the relation between the elasticity, inertia and friction of the system. This is true of the recent course of the metal market as it is of any oscillatory motion. The prices of all metals have broken badly in past three months, and are now exhibiting a series of movements, slight, indeed, but still caused by the waves of sentiment. The phenomena can be compared to a heavily dampened pendulum which makes one movement to a new point of equilibrium and then moves slowly back and forth to that point. Copper, as we all know, was placed at 25 cents last winter by conditions of unprecedented demand and a production restricted by lack of labor and railroad facilities, all these natural conditions being intensified by an artificial market manipulation. It has now sunk to below its own natural level of 15 cents, and although it possibly may stay as low as 12 cents, yet we believe that in the winter it will

return to at least 15 cents, even should its price stay for some time below that figure. Indeed, to the careful observer, the metal markets have made a turn for the better in the last part of October. Consumption is still going on, for this is a great big country and is consuming all the while actually, though change in position of floating stocks between producer, refiner, middleman, brass and copper manufacturer, wholesaler, retailer and actual consumer is always shifting, like a sand hill on the desert, by the winds of trade. And Europe is now buying copper in quantities quite the reverse of its course in May.

* * *

Two reasons for this improvement are the fact that business men have decided that hostile legislation will be checked by public opinion, and no extravagance will be allowed, and, secondly, that we have produced large crops of all agricultural staples above the average in amounts and in values equal to the record crop of 1906. This will give us a large credit balance in our favor against Europe. We, therefore, see a tight money market caused by the financing of these crops—strange with our American brains we allow a creation of wealth to restrict trade by a rigid currency system—and the further indication that next March we shall have easy monetary conditions. There are several rocks ahead of us in the metal business. The greatest of these is the high price and inefficiency of labor. Managers would not be perplexed at increased wages were it not for the arrogance of labor when it has gained its point and the fact that when paid more they work less. This is increasing the cost of production of all metals, and certainly this question must be met, seen and conquered by the peculiar genius of the American people for solving new problems in new ways. But this is looking ahead too far, as we are neither prophets nor sons of prophets. For the immediate future, sentiment is adjusting itself to facts, and the healthy recession in business which we hear preached is arrived. But the panicky feeling exhibited in runs on banks and trust companies is foolish. General industry is in good shape throughout this country.

Manual Training Again.

We have always endeavored to bring out in these columns the thesis that the endeavor of the modern industrial world should be to increase the "efficiency of production." It is quite plain that there has been in the past much accomplished in the ways and means of putting capital to good use, and that new natural resources have been created, as it were, by the methods of applied science. The engineer also has had his special training in the modern technical school. But the fourth factor, labor, has, we believe, not had its share of attention. Of course, it is perfectly true that much has been done to improve and ameliorate the condition of the workman, and that his "wage" return is far greater than it was one hundred years ago, but public opinion has been little turned to the question of increasing his efficiency, simply viewing him as a part of the industrial machine. We are particular not to say that his efficiency has not been bettered, for it is manifest that the good clothes, house, food now afforded him have accomplished this to some extent. But we do say that this has been accomplished by no set scheme of those directing affairs of the industrial world but only by more or less haphazard means.

* * *

Leaving aside all question of the good to the state that would arise from a well laid out plan by the leaders of thought, but basing our presentment entirely on the criterion of dollars and cents, it cannot be denied that nothing will increase our nation's wealth so much as to teach the workman how to make a living and also to teach the workman to know how to live. We cannot see what profit it is always to put in high-priced machinery, when it is possible by increasing the number of skilled workmen to do equally as good work with cheaper machinery. There should be a balance between cost of installation and wage. It would seem that our American endeavor has been to exaggerate the importance of the complex and wonderful machine and to neglect the more complex and more wonderful machine—the human being.

* * *

One of the easiest ways to improve the efficiency of labor is to establish in each State a State's system of manual training with loose national supervision, on the pattern of the Agricultural Department. In these schools correct methods of handicraft would be taught. There are a great many boys who have not the capacity for abstract thinking, but nevertheless have plenty of common sense about concrete things. For these, who are to become the foreman and skilled artisans in the industrial armies, nothing could be better than training in a trades' school. This is especially true of the mineral industry. The essential facts about the action of a Wilfley table, for instance, could be explained in such a school. We do not need to go into further details, for the real want of such a system of schools is too apparent. The State of Wisconsin, which seems to be about as far advanced in educational matters as any State, has undertaken to found such a school for the mineral industry, where earnest effort will have a chance. We doubt not that such an enlightened course will have good results. Indeed, it would not be unexpected if some of the big men of the future would be evolved from just such schools. It seems a suitable soil. But these schools should also do more; they should teach the art of right living as well as the trade of earning a living. A broad humanistic spirit present if these would have a wonderful influence for better things in the army of toil. The oddities and crudities of many a workman come from the fact that his being is dwarfed by his environment. Give him half a chance to grow along right lines and the result will be surprising. Especially to be commended in this connection is the attempt of Postmaster-General Meyer to found a postal savings bank throughout our country. This will give the workman a chance to keep his savings under the guarantee of the national government. The annual increment to our savings from this source might be enough to build the Panama Canal. There would be considerably fewer gamblers, prostitutes and barkeepers in the Western mining camps, but a great many more contented workmen. Viewing the whole subject of advance in the industrial efficiency of the workman "en perspectif," we believe that a system of manual training schools and postal savings banks, coupled with a few more good ideas from those aristocrats of our democracy, the leaders of public thought will increase the wealth both material and moral of the country and, by inductive example, of the world.

The Iron and Steel Market.

October has brought forth definite developments. The first important downward trend of the curves of prices and productions has been made, and the movement has been quite in line with what has naturally been in view for months. As long ago as last March this review said: "It is clear that the crest has been passed in the iron and steel trade. * * * The indications thus are that while the greatest activity should prevail for six or nine months to come, there will be some recession in demand late this year, and in 1908."

This prediction has been verified even more closely than could have been hoped for. The pressure for deliveries upon the large mass of business which then stood upon order books was maintained in a remarkable way through a period of many months of quite niggardly new buying, and steel mills were justified in their claims of early in the year that the orders they had booked were of the soundest description.

This business has played out, and with it has come a slowing down in production. It has come earlier at some points than at others. Tin plate was affected first, the leading interest by the middle of October having barely 30 per cent. of its tin mills in operation. Sheets came next, with a few mills closed. The iron mills, both in the East and in the Central West, operated in October to but a half or two-thirds their maximum capacity. Rail output is to be decreased, but this is partly a matter of season. The No. 2 rail mill at Edgar Thomson will close shortly, to be followed by the other two rail mills in that plant.

The Carnegie Steel Co. is closing steel mills in rotation, according to their economy. Bellaire was closed Oct. 22, and Columbus is following. These plants may remain idle for a long time. Homestead is being closed for a relatively brief period, for repairs.

Pig iron production usually increases month by month after the high humidity of July and August, and September showed an increase over August, the low point of the year, barring March, but instead of the curve trending sharply upward, as it did in the past three years, there is certain to be a sharp drop, much as that which occurred in the latter part of 1903, when the decline was from an annual rate of 17,200,000 tons in October, to a rate of 10,500,000 tons in December. The rate in September of this year was 27,000,000 tons. It requires the courage of much careful consideration to predict a decline in the rate to less than 20,000,000 tons by the end of this year, yet such a prediction seems to be quite in order.

The iron and steel trade has naturally been disturbed by the embarrassments in financial circles and by the involvement of certain of the Westinghouse interests, but as a matter of fact little of the change in the iron and steel situation has been due to these influences. The change was bound to come in any event, due rather to the general pathological condition than to the influence of eruptions at specific points. The iron and steel trade is much freer than it has ever been before from adverse influences due to the impairment of credit. Sales are made on a more strictly cash basis than ever before, and through the consolidations a large part of the production has been taken from the hands of individual interests, which would naturally be large borrowers and put in the hands of strong companies the nature of which brought them to amass large surpluses in cash and quick assets. It is not impossible that these large interests should become financially embarrassed at some time, but this can come only through impairment of their cash resources through a long period of depressed demand, and cannot come directly through the impairment of credit.

Pig Iron.

The pig iron market has become involved through the utter disinclination of consumers to enter upon engagements for 1908 Two or three months ago there was a little buying for 1908 deliveries, at prices lower than were asked for this year's delivery, and it appeared that the market might slide off from its undue elevation without passing over any precipices, but as the time approached there came a positive refusal to discuss next year's business and furnaces have been thrown into the position of making the most they can of this year, without regard to next. Bessemer pig iron has been stubbornly held at $22, valley furnace, when this price has been obviously out of line. Foundry and basic pig have declined, but are still quite out of a line which could merge with what must be done for next year. Basic pig has been sold at $19, valley. Southern pig iron has broken and may reach a basis sooner than Northern iron. It is freely offered on the basis of $17, Birmingham, for this year, against $18 a month ago.

The merchant furnaces are quite indifferent to the situation since there has been little prospect of their selling enough iron fully to engage their capacity, and they prefer to have their hands free to blow out when present contracts are completed. This blowing out process has just begun, but will have become pronounced by the end of November.

Steel.

Substantially all the Bessemer steel works are offering billets in the open market, whereas a month ago the majority were reported as being sold up for the remainder of the year. Bessemer billets have been freely offered at $28, delivered Pittsburg, and can be bought at $26 to $27, f. o. b. some producers' mills. There appears to be a stampede among open-hearth mills, and open-hearth billets are offered at little above Bessemer, with the interesting possibility that open-hearth billets may become cheaper than Bessemer.

Finished Material.

Black sheets have been generally shaded $2 a ton, while it is regarded as only a matter of mills catching up in deliveries for galvanized sheets to follow suit. There are rumors that steel bars are being shaded $2 a ton by important interests. Light rails have been reduced $3 a ton. Plates and shapes, and of course standard rails, are firm. Iron bars are extremely irregular, and cannot be quoted.

New demand is extremely light all along the line, except that there is a good movement in wire products. Producers are working on the tail end of old orders, which are holding out better in plates, shapes and steel bars than in other lines.

Regular mill prices are unchanged and we quote them as follows, it being noted that black sheets at least are being shaded, these prices being f. o. b. Pittsburg, per 100 pounds:

Structural shapes, $1.70 for beams and channels, 15 inches and under.

Plates, $1.70 for tank quality.

Merchant steel bars, $1.60, base.

Sheets, 28 gauge, $2.60 for black, and $3.75 for galvanized.

Tin plates, $3.90 for 100-pound cokes.

Application of the Laws of Physical Chemistry in the Metallurgy of Iron.*

By Baron H. von Jüptner.

There is at the present time an almost daily increase in the cases in which industrial practice is profiting by the application of the laws of modern physical chemistry. Whilst in earlier publications on the application of physical chemistry to the metallurgy of iron the doctrine of the phase rule in its application to iron alloys and slags was chiefly dwelt on, the author will in the present case deal with the doctrine of chemical equilibrium as applied to metallurgical chemical processes.

But before we enter upon this it may be well to explain

*A paper read at the Vienna meeting of the Iron and Steel Institute, September, 1907. Slightly abstracted. Abstracts of all other papers presented at that meeting were given in our October issue.

the subject shortly, and in such a manner that on the one hand a clear mechanical view of the working capacity of chemical reactions, and on the other hand a true scientific treatment of the inner working of the problems may be obtained.

I.

All chemical processes are conditional upon the affinity of the reacting bodies. If the value of these affinities (which vary, however, with the physical conditions of temperature, pressure, etc.) are known, it may be foretold in every individual case, from mathematical reasoning, what chemical alterations will take place in any given reacting mixture.

In order to obtain a thoroughly comprehensive idea of the chemical affinities we can best start with the phenomena attending evaporation.

If we partially fill an empty closed vessel with a liquid and evaporate this until a certain vapor pressure is reached, the degree of this will be solely connected with the temperature employed.

If now we attempt to increase the vapor pressure above the liquid, either by decreasing the space the vapor can occupy by pressing down the piston or by pumping in vapor from the exterior, we shall not succeed. We shall only effect the condensation of a part of the vapor, so that the vapor pressure p, which bears on the fluid, remains constant.

The reverse of this experiment, that is, the attempt to diminish the vapor pressure above the liquid, either by raising the piston or by exhausting vapor out of the vessel, also does not lead to the desired result. We only succeed in evaporating more of the fluid, so that the vapor pressure still remains unaltered.

The two examples described show us, therefore, what we actually do is either to pump vapor into the liquid or out of it. The work which we have to do in order to condense in this manner a certain quantity, for example, 1 gram-molecule of vapor, or, what is the same thing, the work, which the fluid performs when a certain quantity of it is evaporated, and which we will call the molecular evaporation energy, can be readily calculated. As the measure of the same, the maximum pressure of vapor (the vapor tension), or what is not only more exact, but also, as we shall soon see more convenient and suitable, the logarithm of this pressure, may be employed.

Quite similar phenomena to those of evaporation take place on the dissociation of such solid or liquid bodies that develop a gaseous constituent. Thus, for example, if we heat calcic carbonate in a closed vessel to a sufficiently high temperature, a part of it decomposes into CaO and CO_2. This goes on until the partial pressure of the CO_2 set free reaches a certain value dependent on the temperature (we will denote this pressure by $[CO_2]$). If we keep the temperature constant, we can by pumping in CO_2 or by pressing down the piston, bring about the reformation of $CaCO_3$. On the other hand, we can by pumping out CO_2 from the vessel bring about a further decomposition of the $CaCO_3$.

Thus we can here also, exactly in the same way as with the vapor, pump the CO_2 *out of* or *into* the $CaCO_3$. The energy which we must employ in order to extract one molecule of CO_2 from $CaCO_3$, or to combine it with the CaCO, that is the work necessary in order to form or to decompose one molecule of $CaCO_3$, can be calculated just as in the former case, and the maximum pressure of CO_2 which is observed (and which is designated the tension of dissociation), can be considered as the mass of the work.

In air saturated with moisture no water can evaporate. In a similar manner $CaCO_3$ cannot be dissociated in CO_2 above its dissociation pressure. If at the commencement there should not be so much water vapor or CO_2 in the space occupied by the gas as corresponds to the maximum tension then water vapor will evaporate or CO_2 will be developed until such a maximum pressure is reached.

If a body on dissociation gives out two or more different gases there is a special dissociation pressure for each of them, at which the decomposition ends. Solid NH_4Cl decomposes on evaporation almost entirely into NH_3 and HCl. This decomposition will obviously stop when the partial pressure of these two bodies $[NH_3]$ and $[HCl]$ has attained a certain maximum value. Now, since by the decomposition of the NH_4Cl equal quantities of NH_3 and HCl are formed, the partial pressure of both must be equal, that is to say,

$$[NH_3] = [HCl];$$

and the total pressure which is necessary in order to prevent the decomposition of the NH_4Cl must obviously be

$$P = [NH_3] + [HCl] = 2[NH_3] = [HCl].$$

If, however, there should be in the space in which we want to volatilize the sal-ammoniac, evidence of the two decomposition products already present a smaller quantity of ammonium chloride will be evaporated than if this were not the case, and it might be thought that the volatilization could be prevented if the partial pressure of the NH_3 thus originally present were as great as the maximum NH_3 pressure, which could be produced by the decomposition of the sal-ammoniac. This, however, is not correct. Even if the partial pressure of the ammonia originally present be far greater, there is always a certain quantity of the sal-ammoniac volatilized or decomposed. Here is the law for a given temperature:

$$\log [NH_3] + \log [HCl] = K.$$

But these proportions become rather more complicated if the decomposition products produced at this temperature are present in unequal molecular quantities as by the decomposition of HgO,

$$2HgO = 2Hg + O_2.$$

Since our amount of work applies to every single gas molecule produced, we clearly have

$$2 \log [Hg] + \log [O_2] = K.$$

We may look upon the above-mentioned dissociations as a kind of volatilization, and so arrive at the following general scheme for the phenomena of volatilization:

1. The body volatilizations as a whole, without recomposition (volatilization in the restricted sense).

2. The body volatilizes as a whole, but in so doing is decomposed solely into gaseous decomposition products (for example, HgO.NH_4Cl, etc.).

3. The body only partially volatilizes; it is thereby decomposed, and besides gaseous decomposition products, forms a solid or liquid residue (for example, $CaCO_3$).

4. The body furnishes gaseous decomposition products, but is at the same time also volatilized undecomposed.

All that has been said above applies also to the solution of solid bodies; only then in place of vapor tension or the tension of dissociation, the tension of solution and the osmotic pressure must be considered.

We can, therefore, assume for every compound solid body a tension of dissociation dependent solely on the temperature, and if this is known for any materials, we can therefrom determine their mutual influence. Of course, we must know the law according to which the tension of dissociation alters with the temperature, but we will here confine ourselves to saying that the first increases with increasing temperature.

If we heat a mixture of BaO_2 and BaO in air to a moderate temperature, the tension of dissociation, or in other words, its oxygen pressure, is lessened, and in fact is smaller than the oxygen pressure in the atmosphere (0.21 atmosphere). Due to its excess of pressure the atmospheric oxygen will be absorbed by the BaO, that is, it will oxidize this latter into BaO_2. If we increase the temperature further, the tension of dissociation of the BaO_2 is increased gradually and finally becomes greater than the oxygen pressure of the atmosphere, and then BaO cannot be further oxidized into BaO_2, but on the contrary this latter will be decomposed. Upon this the

well known process of Boussignault for obtaining oxygen from the atmosphere is founded.

There is also a certain sulphur tension for lead sulphide and for iron sulphide for every temperature, and indeed in the smelting of lead the temperature employed for the reduction of FeS is smaller than that for PbS. Sulphide of iron, therefore, does not act upon lead, whilst iron decomposes molten lead sulphide. There is, therefore, formed sulphide of iron and lead $PbS + Fe = FeS + Pb$; and upon this the so-called "precipitation" process depends. These few examples may suffice to show the importance which the knowledge of the dissociation processes possesses.

(To be Concluded.)

Cost of Water Power.

The following data on the cost of developing the water power which supplies the electrolytic plant at Vallorbe, in Switzerland, with current will be found of interest. They are taken from a recent issue of the London *Electrical Review*. The height of fall is 70 m., the power utilized amounts to 3,000 h.p., and the output of the works is 900 to 1,000 tons of chlorates per year, calculated at the round figure of 1 ton per horse-power day. The expenditure was allocated as follows:

Concession and land	$6,000
Dam	4,000
Tunnel, etc.	10,000
Pipe line	6,000
Turbines and sluice-gates	22,000
Buildings	4,000
Dynamos	60,000
Sundries	8,000
	$120,000

Thus the cost per horse-power was $40. Interest and depreciation at 10 per cent make $4 per horse-power per annum. These results are exceptionally favorable; more usually, it is stated, the cost of installation would average $80 per horse-power, and the annual charges $8.

CORRESPONDENCE

A Metallurgical Revival.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—One of the most extraordinary things of the present time is the revival of old methods as new to the rising generation.

The "Lash process," as described in your issues of August and September, was used at Landore, South Wales, nearly thirty years ago, and was then called the "Batch method." The late Sir William Siemens was very "sweet" upon it. We used "purple ore" from the sulphuric acid works, which we could get very cheap, and other ores mixed with cast iron borings and turnings from Woolwich Arsenal and other works, and we also had some black sand from New Zealand.

It worked well and made good steel in the open-hearth furnace, but died from lack of cast iron borings in sufficient quantity. We added carbon, such as coke and coal dust and ordinary fluxes. I still have my notebooks on these "Batch" charges, but they are stored away in Pittsburg, Pa.

It is a very good method and works well, and I have often wondered why it was not revived. I think some account of these "Batch" charges may be found in old numbers of the *London Institute of Civil Engineers, Journal* of Iron and Steel Institute, and *Journal* of the (London) Chemical Society and Society of Arts. I know Sir William described it in some of his lectures.

On page 300 of your September issue is an article by Dr. O. Nagel on the "Use of Producer Gas, Etc." The drawings shown are almost exactly like some made in Sir William Siemens' office thirty years ago.

Sir William Siemens was a great inventor and experimenter, and I often think of a remark he made to me after we had melted steel in the first electric furnace with a gas producer and gas engine for power. He said: "It will take a quarter of a century for these experiments of mine to come into practical use; you may live to see it, but I shall not." I see the truth of his remark now.

Walter E. Koch.

(For ten years engineer with the late Sir William Siemens.)

El Paso, Tex.

Gas Analysis.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—On pages 350 to 352 of the September issue of your journal, Mr. Edwin Barnhart describes a very practical apparatus for gas analysis, which appears to be complete except that no provision is made to prevent the burette stopper from jumping out should any pressure occur in the burette.

I should like to enumerate some of my (and also others') experience regarding the absorption of the last traces of carbon monoxide. I have found it most accurate to pass the gas from the ammoniacal cuprous chloride solution, where most of the carbon monoxide has been absorbed, to another pipette containing a very slightly used ammoniacal cuprous chloride solution, where the last traces of carbon monoxide are quickly and entirely absorbed. The disadvantage of using an acid solution of cuprous chloride, as Mr. Barnhart describes, is that the absorption of carbon monoxide is never quantitative, as the compound dicarbonyl cuprous chloride (Cu_2Cl_2, $2CO + 4H_2O$) formed is of a very unstable nature in acid solution, and it requires a certain counter pressure of carbon monoxide to prevent it decomposing, as follows:

$$Cu_2Cl_2,\ 2CO = Cu_2Cl_2 + 2CO.$$

This reaction is reversible, and when an excess of carbon monoxide is present reacts from right to left, but when an acid solution of this compound is shaken with a gas rest containing no carbon monoxide the above reaction takes place from left to right and carbon monoxide can be detected in the gas rest.

For exploding the gas rest I have found it quickest and most convenient to use very slightly acidulated water instead of mercury, which is rather cumbersome for very rapid work, and I also use this water in my burette so that the ammonia is readily absorbed, and after the explosion the water does not absorb any of the carbon dioxide formed.

Perth Amboy, N. J. Herbert Philipp.

Carbons for Electrometallurgy

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—I have just received Vol. XI. of the *Transactions* of the American Electrochemical Society. On page 324 there is printed the discussion following the paper presented by FitzGerald and Forssell, and any one who takes the trouble to read this will certainly be puzzled.

The discussion as printed opens with a communication from FitzGerald and Forssell, which gives the result of an investigation of a certain phenomenon unexplained in the paper and the subject of the discussion which followed. As the communication from FitzGerald and Forssell finally settled the matter that was under discussion, it should be read as a communicated discussion *after* the discussion which really took place at the meeting.

Francis A. J. FitzGerald.

Niagara Falls, N. Y.

NEW YORK MEETING AMERICAN ELECTROCHEMICAL SOCIETY.

The twelfth general meeting of the American Electrochemical Society was held in New York City on Thursday, Friday and Saturday, Oct. 17, 18 and 19.

On the evening of Oct. 17 a reception was held at the Chemists' Club, and after the President, Prof. C. F. Burgess, had called the meeting to order, two lectures of general interest, illustrated by lantern slides and demonstrations, were presented. Dr. Geo. F. Kunz, the well-known gem expert of Tiffany & Co., spoke on diamonds and moissanite, natural, artificial and meteoric, while Mr. E. G. Acheson, whom Dr. Chandler called the "Wizard of Niagara Falls," spoke on deflocculated graphite. Abstracts of these lectures are given below.

The morning session of Oct. 17, held at the Chemists' Club, and the morning session of Oct. 19, held at Columbia University, were devoted to the reading and discussion of papers. Full accounts of the papers presented will be found below.

In the afternoon of Friday an excursion was made to Llwellyn Park, Orange, N. J., to visit the laboratories of Mr. Thomas Alva Edison. Mr. and Mrs. Edison received the party in the library in a very cordial manner, and the visitors were conducted in small parties through selected portions of the laboratories and the phonograph works. It appears that the celebrated nickel-iron storage battery, to which Mr. Edison has devoted the last ten years in hard and continuous work, is about to re-enter the market after several improvements have been successfully made. Considerable attention was paid to the model of an all-concrete $1,000-house for workingmen, a wholesale manufacture of which is Mr. Edison's latest scheme. The New York dailies of the next morning devoted considerable space to the project.

On the evening of Friday a dinner was held in the beautiful banquet hall of the German Liederkranz Society. It was very well attended and was a delightful affair. Prof. C. F. Chandler was, as ever, a magnificent toast-master, toasts being responded to by Prof. C. F. Burgess, Prof. S. A. Tucker, Dr. J. W. Richards, Mr. E. G. Acheson, Dr. W. R. Whitney, Dr. Henry Noel Potter, Dr. Charles Baskerville, Mr. J. Hasslacher, Mr. Draeger and Prof. M. T. Bogert. Vocal selections, presented by the young Liederkranz Quartette, Messrs. Theo. Trautmann, Edw. L. Seip, N. C. Latterner and Jos. M. Kahn, were greatly enjoyed.

PHOTOGRAPH TAKEN AT THE BANQUET IN LIEDERKRANZ HALL.

For the afternoon of Saturday two excursions had been arranged, one to the new power plant of the Pennsylvania Railroad at Long Island City and the Electrical Testing Laboratories in New York; the other to the magnificent and recently greatly enlarged plant of the United States Metals Refining Co. (De Lamar refinery) in Chrome, N. J., where the process of copper smelting, converting and electrolytic copper refining and the electrolytic parting of dore bullion were shown in operation.

The meeting was concluded by a very enjoyable smoker, tendered to the Society by the Chemists' Club at its club house on Saturday night.

In the following we give abstracts of the papers which were presented at the meeting. No attempt is made to give them in the order in which they were read, but rather to group those together which deal with kindred subjects.

Silicon Monoxide.

Three exceedingly interesting and valuable papers on silicon monoxide were presented by Dr. Henry Noel Potter. Of these the first, presented in the Friday session, discussed the scientific questions involved in the problem, while the two other papers which were presented in the Saturday session dealt respectively with the properties of the brown powder "monox" (silicon monoxide) which determine its commercial applications, and with the electric arc furnace for making monox.

In the scientific paper, Dr. Potter points out that theoretically silicon, like carbon, should have a monoxide as well as a dioxide, but in the case of silicon only the dioxide has been recognized. Clemens Winkler attempted to form silicon monoxide, and reports: "It is supposed that SiO does not exist, for even in heating a mixture of SiO_2 and Si, the reaction $SiO_2 + Si = 2SiO$ does not result."

As this experiment was performed in a combustion furnace, under conditions where the maximum temperature probably did not exceed 1,000° C., the conclusions based thereon can only be accepted within the temperature range involved.

If the Winkler experiment be extended to temperatures attainable with ease in the electric furnace, a brisk reaction takes place, with liberation of a brown smoke which burns to silicon dioxide. If the reaction is effected in an inert atmosphere in a furnace of the resistance type, the smoke can be collected as a soft, brown, very fine and voluminous deposit upon all exposed surfaces within the furnace.

Dr. Potter gives details of the analyses of samples of this brown deposit and the calculated amounts of SiO contained in it. Before declaring that in these experiments the reaction

$$Si + SiO_2 = 2SiO$$

has been realized, Dr. Potter discusses in detail two objections. First, it might be thought that the reaction was wholly between the carbon of the resistor of the furnace and the silica of the charge, and that the free silicon itself took no part in it. A second objection might be that perhaps no inter-reaction at all took place, and that both silicon and silica were distilled, side by side, without reacting upon each other.

Both objections are clearly proven to be not valid, and it is conclusively established that silicon can and does reduce its own dioxide (the reaction being quite brisk at temperatures between 1,700° and 1,800° C.) with the production of a lower oxide, which analysis indicates to be the monoxide. As high temperature products are usually characterized by simplicity of composition, the formula may be assumed to be SiO.

If carbon or silicon carbide be used as reducing agent in place of silicon, the brown powder is produced in voluminous quantities. An arc furnace can be substituted for the resistance furnace, and the yield per unit of electrical power employed considerably increased. With increased heat concentration, however, the amount of silica distilled appears to be increased, as the percentage of total silicon in the brown powder decreases.

While the proportion of silica to reducing agent has practically no effect upon the proportion of silicon in the product, it nevertheless has a considerable influence upon the yield.

This was shown in a number of runs using carborundum as reducing agent and varying the composition of the charge. The highest yield was obtained when the charge was made up according to the formula:

$$2SiO_2 + SiC = 3SiO + CO.$$

If the proportion of carborundum or of silica was increased the yield was reduced in either case. With purified carbon as reducing agent, the highest yield was obtained with the theoretically correct mixture according to the equation

$$SiO_2 + C = SiO + CO.$$

In view of the chemical analogy between carbon monoxide and silicon monoxide, it would seem theoretically possible that, even though silicon monoxide does exist as such at electric-furnace temperatures, nevertheless, on cooling, it would dissociate in accordance with the formula:

$$2SiO = SiO_2 + Si.$$

A great deal of chemical investigation was gone through with by Dr. Potter to find if possible some property of the brown powder which should be different from any possible property of a mixture of silicon and silica.

It was thought for a time that such a property had been discovered when it was found that the brown powder, when freshly prepared, dissociates water with the liberation of hydrogen. This reaction takes place slowly with ice water and is brisk with boiling water. The evolution of gas, however, soon ceases, due doubtless to the coating of silica produced upon the particles by the reaction.

It was subsequently found, however, that both crystalline and amorphous silicon have this property of dissociating water, provided the surfaces of the particles have not had opportunity of becoming covered with a protecting film, which they soon acquire on exposure to the atmosphere.

This property of silicon can be quite readily shown by dissolving off the film with hydrofluoric acid, and after washing off the acid in cold water, throwing the new active silicon particles into boiling water. In the case of finely granular silicon, the hydrogen liberated will adhere to the particles and float them up to the surface.

The thickness of this film was determined, and assuming the particles to be cubes 0.001 millimeter on a side, the thickness of the film was calculated to be 0.00000016 millimeter. This is a thickness which is small, even in comparison with a length of a single wave of violet light. The presence of this film doubtless underlies the successful application of silicon crystals as receivers for wireless telegraphy.

No chemical test could be found which would enable one to distinguish silicon monoxide from a mixture of silicon and silica, such as would be produced by the dissociation of silicon monoxide. Dr. Potter, therefore, undertook physical tests.

The first investigation along this line was to measure the heat of combination of the brown powder in a special bomb calorimeter.

The heat of combustion observed must be due either to the combustion of

$$2Si + 2O_2 = 2SiO_2,$$

or

$$2SiO + O_2 = 2SiO_2.$$

In the former case the heat of combustion should be that of amorphous silicon, in the latter it may be different, just as the combustion of two molecules of carbon monoxide yields more heat than the combustion of one atom of carbon.

The end result of the extended and exceedingly careful determinations of Dr. Potter is that, that on the whole, the heat of combustion of the brown powder varies from sample to sample, but that it is consistently higher than can be explained on the basis of the combustion of silicon in any known form.

Dr. Potter's figure for the combustion heat of his crystalline silicon is 7,505 gram calories per gram of silicon burned.

Dr. Potter's brown powder, which is essentially silicon monoxide, is different from Mr. Tone's brown vitreous material formed in the silicon furnace. The latter is a mixture of silicon and silica in theoretical proportions; it was true monoxide at a high temperature, but in cooling off it has completely dissociated.

The difference which has been shown to exist between the brown vitreous material and the brown powder can be plausibly explained as due to the difference in the conditions surrounding their formation.

The furnace in which the brown powder is now made is the latest of a number of experimental devices, all having the same characteristics, namely, an arc between two opposed

horizontal carbon electrodes, in a closed chamber consisting of a body containing the charge and a cover of considerable volume. The theoretically important conditions are that the charge should surround the arc, that the arc should not be buried too deeply beneath the upper surface of the charge, that the hollow space or crater which forms about the arc when it operates shall soon work to the surface of the charge and break through into the empty space above, forming a discharge throat, and finally that this empty space shall be large enough and so shaped that the bounding walls nowhere approach the throat near enough for the highly heated blast of gas therefrom to strike them.

When the furnace has been in operation long enough for the crater to have formed a throat, and the normal process to be in operation, the reaction occurs on the inner walls of the crater. The silicon monoxide is apparently released in the gaseous state, enabling it to rush out of the crater almost instantly, along with the liberated carbon monoxide. Once out of the throat, the gases expand very rapidly and are instantly chilled so that the silicon monoxide does not have time to completely dissociate before it is brought down to a temperature at which its speed of dissociation is practically zero, all of which is in strict analogy with the known dissociation phenomenon of carbon monoxide, the only difference being that silicon monoxide happens to be a solid and not a gas at ordinary temperatures.

It would appear that silicon monoxide is a sublimate, as the author has not been able to liquify it in a tubular resistance furnace at a temperature of 1,700° C. The sample pieces grow smaller, but the edges remain sharp, indicating sublimation without softening.

The brown vitreous material is apparently produced by the cooling gaseous silicon monoxide upon the walls of gas passages through the charge material in the furnace, and owing to its slow cooling, dissociation has ample time to become complete.

These theories have received a curious confirmation by specific heat measurements. In the case of an ordinary substance obeying the law of Dulong and Petit, it would be impossible by a comparison of specific heats to determine whether the substance examined was a mixture or a compound, but silicon does not follow this law, but has a specific heat, which, within ordinary temperature ranges is too low, but which grows higher and higher with increased temperature

The silicon dioxide follows the abnormal character of silicon in its specific heat, indicating that whatever the cause of the change of the specific heat of a silicon molecule on cooling, it applies to the silicon within the silica molecule.

It has been supposed that compounds consisting of relatively few atoms have a specific heat which is an additive function of the heats of their component atoms, but that where abnormal heat capacity is shown, that this is due to some change in the molecular structure. This is almost the only clue we have to structural changes occurring within the molecule of solid substances.

It seemed possible that in the case of silicon monoxide, which is normally a high-temperature compound and exists at ordinary temperatures only by virtue of an accident of cooling, that the molecular structure must preserve the peculiarities of the normal high temperature condition, and that the specific heat of such a compound should be higher than that of the mixture resulting from dissociation.

This hypothesis was indeed fully confirmed by a very careful research made with a specially designed, very accurate calorimeter of high refinement. It was found that the specific heat of a mixture of silica and silicon in equivalent proportions ("pseudomonoxide") and the specific heat of Mr Tone's brown vitreous material agree well together, the figures being 0.1828 and 0.1833. On the other hand, Dr Potter's brown powder has a specific heat above 0.2. When the brown powder was heated at 400° C. for several hours, and when the specific heat was redetermined afterwards, the lower value 0.18 was found, showing that a molecular change had taken place, which can be readily explained as a dissociation.

To the brown material the name "monox" has been given, this name covering the material in the dissociated, as well as in the undissociated condition, inasmuch as there is no industrial distinction between the two, as yet determined.

The chemical properties have already been touched on. In general they are conditioned by the presence of a film of silica over the particles, so that until this film is removed, the properties are those of silica.

The specific gravity of the brown powder, as produced impure, is 2.24, or 2.191 as SiO after correcting from impurities.

The color dry, is a light-yellowish brown, when wet with water or oil, a darker and more neutral brown. The higher the refractive index of the wetting liquid, the darker the brown. Probably the darkest brown and true color would be seen when the powder is wet with a liquid having the same index as the silica film.

The size of the ultimate particles is very small, it being of the same order as those of soot or carbon blacks.

The heat insulating and electrical insulating properties are high. It is remarkably negative when electrostatically charged by friction. This property, however, seems to depend on fineness of particle, or extent of surface.

The brown powder is extremely opaque, both dry and wet, a property that harmonizes with the idea of at least a partial dissociation, and therefore the presence of an electric conductor, namely, silicon.

This research was carried out for Mr. George Westinghouse, to whom Dr. Potter expressed his great indebtedness "for his patience and continued interest during the long period over which the research has extended."

Monox.

The industrial applications of the brown powder "monox" (silicon monoxide) were the subject of the second paper of Dr. Henry Noel Potter. Various of the properties of monox have already been covered in the above abstract of his paper on silicon monoxide.

The true density of monox is about 2.24, but it is so voluminous as to weigh, when simply shoveled into a box, only about 2½ pounds per cubic foot. It may thus seem to fill over fifty times the space it really occupies.

Dry monox is powerfully negatively electrostatically charged on the slightest provocation, such, for example, as drawing it suspended in dry air through a short rubber pipe When so charged it flies and adheres to all non-conducting surfaces, such as a cotton or other fabric, and in this way it can be filtered out of air or other gas in which it is suspended, and accumulates as a layer over the fabric, without caking together or very materially hindering the passage of gas.

Such a screen, coated with adhering monox is impervious to fine solid particles of any sort such as those constituting cigar smoke or the fine particles formed when gaseous ammonia reacts with gaseous hydrochloric acid Germs and all such organisms are stopped so that air drawn through such a screen is sterile. This is a broad field of application, but has not been thoroughly investigated as yet

Monox has in a remarkable degree the power of thickening fluids with which it is mixed, and this, together with its chemical inertness, its opacity, and its pleasant light color render it a very valuable pigment in certain oil paints, in particular paints for brick work and paints for protecting structural iron from rusting.

In the following table are given the relations by weight and by volume of various pigments and raw linseed oil, when mixed into paints of good thickness to spread properly

Monox paint, owing to its extremely high oil ratio can be used with advantage thicker than the painter is accustomed to handle.

PIGMENT RATIOS.

No.	Pigment.	Sp. Gr.	Approximate Per Cent in Paint by Weight.	Approximate Per Cent in Paint by Volume.	Weight per Gallon. Lbs.
1	White lead.....	6.43	80	36.6	21–24
2	Red lead.....	8.53	88+	45.4	30–35
3	Zinc oxide.....	5.60	57+	18.1	14.8
4	Iron oxide.....	....	..	....	15.6
	Indian red.....	4.32	64+	27.5	....
5	Ochre.....	2.07	50	25.7	11.8
6	Monox.....	2.2	20	10.2	8.6

With certain reservations necessary in any general statement concerning such a complicated subject as the weathering of paint, the paint having the highest volumetric ratio of oil should be the most durable, whether on iron or wood or stone. In all these respects monox is excellent and in direct competition with other pigments in practice has shown most gratifying durability.

Another somewhat kindred application of monox is for making inks. The contribution of monox to black printing ink containing it is to make the ink "lay" perfectly and dry with a dead lustreless black, which will not easily offset. In higher grade inks the color is always improved by adding a blue or other "toning" color, and these "toners" help to make the ink lay in some cases, but as their function is to color the ink, the amount introduced must be limited to that giving the desired tone, whether the ink lays or not. There is thus a chance to introduce a third ingredient beside black and toner, whose function is to make the ink lay. This monox does very nearly perfectly.

A further application of monox is in ceramics. All ceramic materials contain silicon and are fired to render them permanent in form or location. Many of the technical difficulties are due to the firing. As monox may burn to silica under proper conditions of mixture with oxides or exposure to oxidizing flame, it may, in certain cases, be substituted for a part or all of the silica with advantage. In burning to silica, monox liberates considerable heat, and thus a sort of suto-firing may occur. This seems to promise certain advantages in glazes and in other departments, but it is at present too early to definitely state.

Other experiments made by Dr. Potter and briefly noticed in the paper referred to the use of monox as a lubricant, as a polishing powder and as a heat insulator.

Electric Furnace for Making Monox.

Dr HENRY NOEL POTTER'S third paper describes the electric furnace in which monox is made. A diagram of the furnace is shown in Fig. 1.

Silicon monoxide is produced when silica, ordinarily in the form of glass-maker's sand, is heated in contact with coke, graphite, silicon carbide, silicon or intermediate reducing agents, such as siloxicon and carborundum fire-sand containing silicon, carbon and oxygen.

Under the usual conditions of electric furnace arrangement and operation, the silicon monoxide cannot escape and is further reduced to silicon or to silicon carbide. It exists under such conditions only transiently, but can be shown by inserting a carbon tube into a furnace which is producing silicon. Through this tube, a brown smoke and gases may be drawn, representing the condensed atmosphere within the furnace. This will be found to contain monoxide in abundance, but little or no free silicon. This appears to be due to the high boiling point of silicon, which lies higher than the sublimation temperature of silicon monoxide, so that on gaseous silicon monoxide being reduced, liquid silicon results, which collects into drops and trickles down the walls and so collects in the pool where it is found.

The liberation of both silicon monoxide and carbon monoxide as gases, causes an elevation of gas pressure at the place of reaction. If the thickness and weight of charge above the region of reaction is not great, and if there is a free space above the charge, the gases will work their way upward and outward with such force as to open a passage through the overlying charge, and through this passage the hot gases will rush, widening it out into a throat and piling up a cone of displaced material about the throat opening like a little volcano.

Under such conditions there can be no great increase of gas pressure in the reaction region, and the gases as soon as they form, burst out through the throat in an incandescent blast.

Thus it happens that the silicon monoxide does not remain long enough in the reaction region to become fully reduced, but escapes almost as soon as formed and is chilled very rapidly.

If such a throat discharges silicon monoxide and carbon monoxide into the air, they burn with great violence and liberation of heat, with production of clouds of fine silica. If, on the contrary, the throat discharges into a large container free from air, preferably under reduced pressure, the products in the blast do not burn, but cool with great rapidity and deposit on the walls and all exposed surfaces within the container the fine brown powder "monox."

The present commercial furnace consists of a cylindrical cast-iron drum about 5 feet in diameter, lined with a 7-inch

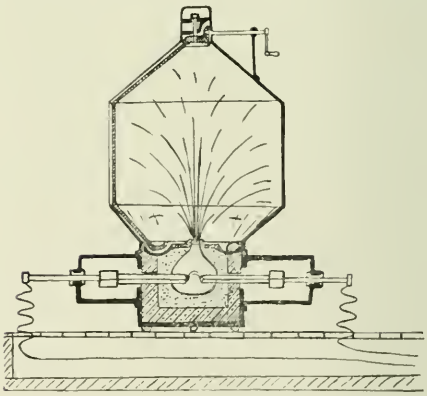


FIG. 1.—MONOX FURNACE.

wall of fire-brick. Diametrically opposite each other are cast-iron terminal boxes for introducing the electrodes.

The terminal boxes have doors provided with rubber gaskets in the form of tubes, through which water under pressure circulates, in service, insuring a gas-tight joint and keeping the gasket and adjacent metal surfaces cool at the same time. These water-cooled expansion gaskets are used in a number of places about the furnace and contribute in no small degree to its success, as they do away entirely with bolts, nuts, and washers, asbestos gaskets and all the time-wasting details of what may be termed standard practice. The doors are shut and the water turned on, and that is all there is to a making a gas-tight fit. When the doors need to be opened, the pressure is equalized inside and out, the water turned off, and the door opens as easily as though it were on a kitchen range.

The electrode clamps are also water-cooled, as otherwise the bolts and nuts get so hot as to stretch and jar. It is the best practice to water-cool all parts where any mechanical action occurs. The electrodes themselves are 4-inch square bars of either Acheson graphite or carbon. These are horizontal and meet in the center of the large brick-lined drum.

The top of the drum is open and a balloon cover fits upon it with a water-cooled expansion gasket to make it tight.

The cover is a boiler-plate cylinder 7 feet in diameter, with a conical top and a conical reduction where it joints the drum.

Within the cover are scrapers which hang from a central spider in the top of the cover and are driven by gears operated by a shaft entering through a stuffing box. The cover is cooled by a film of water which trickles down over its outer surface and is caught in a gutter below. It does not heat up very rapidly and a little water serves to keep it cool enough.

The charge consists of a mixture of sand and coke, or sand and carborundum fire-sand, to which a little coke is added to increase the yield.

The drum is entirely filled with charge to a height of 12 inches or more above the electrodes. The top of the charge is then weighted down with fire-brick, and directly above the arc a graphite ring with a 7-inch opening in its center is laid on the charge and a part of the charge dug away through the ring to make a weak place in the charge so that the reaction gases shall blow out through the ring and thus build the throat in the axis of the furnace. Once the furnace is charged and has been operated, it can be recharged by pouring fresh charge down the open throat.

For providing a vacuum, an air pump of the Abbe Engineering Co. is used.

A very interesting accessory is the special generator which supplies energy to the furnace. It is a rotary field alternator designed to operate a single arc of the full capacity of the machine at or near the top of the volt-ampere characteristic curve of the dynamo. It is separately excited, and can be open circuited or dead-short circuited without injury to itself and without stalling the gas engine driving it.

This generator was designed by Mr Tingley, of the Westinghouse Electric & Manufacturing Co. particularly for this service, and it may be said to be the first of an intermediate type of dynamo between the constant-potential and constant-current types. This may be appropriately termed the electric furnace type, as its peculiar virtue is to maintain an arc without any necessary regulation external to the armature

Analysis of Silicon Compounds.

Mr. A. Bliss Albro presented a paper on a new method for the analysis of silicon compounds. This method has been devised by the author in connection with Dr Potter's work, and in practical use for a number of years it has proven thoroughly reliable.

The author first discusses a number of disadvantages of the usual sodium peroxide method. Among these are the following two, if the silicon analyzed contains carborundum. Since the latter is dissociated by sodium peroxide with the liberation of carbon dioxide, no distinction can be made between any free carbon in the sample and the carbon from the silicon carbide without a separate analysis. Further, the silicon from the carborundum passes into the fusion the same as the free silicon and is credited as existing in the sample in the elemental state

Since it is impossible to give in a brief abstract all the elaborate steps in Mr. Albro's new method (for which reference must be had to his paper in full to be published in the *Transactions*), we will simply notice here Mr Albro's simpler method for checking the impurities contained in silica, silicon monoxide, or ferrosilicon.

After proper sampling and weighing in a platinum dish of about 75c c capacity, the sample is moistened with distilled water and then treated with about 30 c.c of concentrated c.p. hydrofluoric acid and 10 c.c of concentrated c.p. nitric acid. The hydrofluoric acid is added first, and then the nitric acid is added drop by drop, owing to the violence of the reaction. After all reaction has ceased, the solution is diluted and filtered through a weighed, hardened filter paper. This is dried and weighed, the gain in weight being a true measure of the free carbon and silicon carbide in the sample. It is then incinerated, the loss in weight after correcting for filter paper ash being free carbon and the residue silicon carbide.

The filtrate is caught in a platinum dish, evaporated to dryness, treated with a few drops of sulphuric acid, re-evaporated, taken up with sulphuric acid, to which a small amount of hydrochloric acid is added, heated to boiling, diluted with distilled water, boiled until a clear solution is obtained, evaporated until copious fumes of sulphuric acid are given off, diluted with distilled water and treated to determine the iron, aluminium, calcium and magnesium By adding ammonium chloride and ammonia, boiling and filtering a precipitate is obtained which contains the iron and aluminium as hydroxides, while the filtrate contains the calcium and magnesium The silicon is finally calculated by difference.

This analysis has been proved to be accurate to within 0.3 to 0.4 per cent. of the total silicon content of commercial silicon and silicon compounds, as compared with the results obtained by the longer method of Mr Albro This method is especially useful in analyzing ferrosilicon containing less than 75 per cent of silicon The results always show slightly higher silicon values than actually exist, owing to the fact that all the material volatilized by the mixed acids appears as silicon in the final result

Determination of Silicon.

Mr. William Roy Mott presented a paper on electrochemical methods for the qualitative and quantitative determination of free silicon in the presence of silica, silicates, oxides, free carbon and silicon carbide A direct process for determining free silicon consists in the treatment of the material to be analyzed with metallic fluorides, such as copper fluoride, silver fluoride, etc In one step the solid metallic silicon electrochemically replaces the metal in solution, which metal is deposited and may then be weighed or may be dissolved and determined in any regular way. These methods are direct, and are not interfered with by the presence of silica, silicates, metallic oxides, free carbon or silicon carbide.

In the case of silver the formation of pure solution of silver fluoride with hydrofluoric acid is advisable The material to be analyzed can be ground in an agate mortar, which will be partially abraded, as silicon carbide is the harder material but this, however, does not interfere with the accuracy of the result as it does where chemical methods for determining free silicon are used. To determine the total free silicon in the material it is only necessary to grind fine enough to pass sieve No. 150.

The treatment with silver fluoride solution should be made in a platinum dish and continued from 1 hour to a day The reaction of silicon in electrochemically-precipitating metallic silver is $Si + 4AgF = 4Ag + SiF_4$. One atom of silicon replaces four atoms of silver The author has made quantitative determinations where the free silicon formed only about one millionth part of the material analyzed.

Electrometallurgy of Iron.

Two papers presented at the Thursday meeting dealt with the reduction of pig iron from ore in the electric furnace

The first paper, which had Messrs A E. Greene and F S. MacGregor as joint authors, was presented by Mr MacGregor, and gave an account of the authors' research, which has already been fully covered in an article by the same authors in our September issue, page 367

Mr. Greene is now with the Noble Electric Steel Co. in Heroult on the Pit-Shasta County, Cal. As will be remembered this company is to carry out on a large commercial scale the reduction of California iron ore in the electric furnace, cheap electric power from water power being available The pig iron is subsequently to be made into steel. According to a statement of Dr Heroult this will be done simply by an open-hearth furnace, since the pig iron and steel produced will be pure enough to make final steel refining by an electric furnace unnecessary Several successful runs for producing

pig iron in the electric furnace have been made, but until the plant for making the electrodes is completed the company will make only ferro-silicon on a commercial scale.

The second paper presented on the electric reduction of iron ore was a discussion by Dr. Joseph W. Richards of the experiments which were made at Sault Ste. Marie with the Héroult furnace, under the auspices of the Canadian Government, and a detailed account of which may be found in our Vol. IV. Unfortunately, no advance copies of the very interesting paper of Dr. Richards were available, so that it is impossible to give here the numerous thermochemical calculations which were presented by the author in form of tables, etc. However, some fundamental general points were brought out strongly in the paper.

One is that there is no advantage in trying to produce in the electric furnace a pig iron containing a certain amount of silicon. By doing so the two different problems of iron oxide reduction and silica reduction are mixed up. It is preferable to simply reduce the iron oxide, and later on add any silicon which may be desired in form of ferro-silicon.

A second and even more important point brought out by Dr. Richards was the necessity of properly proportioning the amount of carbon in the charge. Since in the electric furnace carbon acts simply as a reducing agent, and since in a given charge of ore there is only so and so much iron oxide, the oxygen of which can combine with the carbon, it will be evident that so much carbon should be used as is able to combine with the oxygen in the ore to form carbon dioxide. If more carbon is used some carbon monoxide will be produced, and the amount of carbon monoxide in the gases will be the higher the greater the proportion of carbon in the charge. To control the proper working of the furnace it is of the highest importance to analyze the furnace gases, and this has been generally neglected in experimental researches of this kind. This is a matter to which far more attention should be paid in future.

It also follows directly that within certain limits the less the amount of carbon in the charge the higher is the utilization of its calorific value in the electric furnace, and therefore the smaller the amount of electrical energy required. It seems that in the tests at Sault Ste. Marie generally too much carbon was used.

We hope to come back to Dr. Richards' interesting analysis more in detail in a future issue.

Mathematics of the Induction Furnace.

A paper by Mr. Gustave Gin, of Paris, on the theory of the induction furnace was read in abstract. In the first part of his paper Mr Gin gives the fundamental formulas of a transformer with large leakage fluxes. The formulas are applied to show how the power factor in the primary and the power consumed in the secondary vary when the resistance of the secondary increases from zero to an infinite value. It is shown that for a certain value of the secondary resistance, the power consumed in the secondary is a maximum. In the second part of the paper Mr. Gin makes an attempt to calculate the various stray fluxes if the double magnetic circuit consists of two rectangular iron frames, placed vertically side by side, the secondary encircling the two vertical inner legs. Two primary windings are used in series, one on each frame. Mr. Gin considers the following two cases; in the first the two primary windings are placed on the outer vertical legs of the two frames; in the second they are placed on the upper horizontal arms. From his formulas Mr. Gin concludes that the latter arrangement is preferable. Another conclusion is that it is preferable to connect the two windings in series instead of in parallel.

In the discussion which followed the inherent necessity of having the secondary at a considerable distance from the primary was referred to. Mr. Carl Hering pointed out that the effect of the heat on the primary windings is not the most serious point, since it is possible to use asbestos-insulated and water-cooled coils, but the high temperature has a very detrimental effect on the iron forming the magnetic circuit in lowering the permeability. Dr. E. F. Roeber thought that for the sake of getting a working theory of the induction furnace, it would be preferable to start with the well-known formulas of the induction motor. Both the induction furnace and the induction motor are special cases of the general transformer, and they have in common the special feature of high-leakage fluxes. How far it is possible to take over bodily the formulas of the induction motor to apply to the induction furnace, must be determined experimentally.

Electrometallurgy of Zinc.

A paper on this subject by Mr. Gustave Gin, of Paris, was presented in abstract by Dr. J. W. Richards. The author first discusses the imperfection of the present methods in zinc metallurgy, and gives a review of various proposals which have been made as to the use of electrolytic or electric furnace methods in the metallurgy of zinc. He then gives an account of his own work in this field.

Mr. Gin first tried an electric furnace with electrodes, but he found the difficulties in using the electrodes in a closed vessel to be so great that he concluded to adopt the induction furnace for his purpose. "Suppose that in the channel of the induction furnace there is placed a metal in the state of fusion. Any material put in contact with this metal will be decomposed if it is able to form with the same another compound more exothermic than the first. It is thus possible with a given metal to set other metals at liberty. If the metal set free is capable of alloying with the first their alloy will result. If the metal set free is volatile it can be collected by condensation. This is the case when zinc oxide and sulphide are reduced by iron at a temperature above 1,300°. It is equally possible to limit the action of the iron to that of a conductor and producer of heat, and to utilize this heat to provoke reducing reactions in the mixture of carbon and metallic oxide or silicate, or of carbon, lime and metallic sulphide."

In order to get efficient circulation, Mr. Gin modifies the ordinary construction of the induction furnace by using as his crucible a series of channels, the bottoms of which are inclined longitudinally, the deepest part of each being connected by a conduit with the more shallow part of the next channel. The channels have a relatively large section so that the fused material, while filling completely the conduits or connections from one channel to another, only occupies a part of the sections of the channels themselves.

The quantity of electric energy transformed into heat varies inversely with the section of the conductor; the molten mass is for this reason cooler in the top parts of the channels than in the other extremity. By reason of the difference of temperature, and consequently of density, there results an ascensional movement of the liquid in the connecting conduits, reinforced by the further heating in the conduit itself, and by reason of this produces a general circulation throughout the whole mass, forming the secondary circuit.

The construction of the furnace is shown in Fig. 2, in which diagrams I., II., III. are vertical sections and IV. a horizontal section. The channels with exposed surface, called the working channels (a), are placed parallel to each other, their bottom longitudinally inclined and united to conduits (b) of circular section, called the heating conduits, which have the lower parts of each channel in connection with the more shallow parts of the following channel.

The primary circuit is composed of an insulated copper coil around the upper horizontal branches of the double magnetic circuit (cc). The two coils constituting the primary (dd) have the same number of turns and are connected in series.

The secondary circuit is constituted by the bath of liquid iron contained in the channels (a) and the conduits (b).

To protect the conducting cables from the radiation of the

hot masonry there are interposed between the inside faces of the magnetic coil and the adjacent masonry, metallic channels (e) cooled by a current of water. The masonry does not rest directly on the lateral faces of the inductor, but is supported on plates which themselves rest on pins. The water for cooling passes between these plates and the inductors.

A fan is used to send a current of air around the magnetic core and the primary winding, so as to keep them cool. The air is led in through trunnions (f) and is distributed by the boxes (g). Dampers, movable by chains, pullies and an endless screw, permit a regulation of the circulating air and its proper distribution. The whole furnace is contained in a sheet iron shell resting upon two trunnions (f).

The lining of the furnace is formed of burnt dolomite, agglomerated by pitch and stamped in like the hearth of the Siemens-Martin furnace. The roof is made of bricks of burnt magnesite, the contraction of which is practically nothing.

The bath of iron being at a suitable temperature, there is spread upon its surface by a charging device, similar to that used for charging gas retorts, a mixture of the oxide of zinc and carbon or of the sulphide, lime and carbon. When the charging is done, the working door is quickly closed and the joints plastered up with clay to prevent the entrance of air. Continuing the heating the temperature of the mixture is raised rapidly and the distillation of the zinc commences.

Zinc vapor and the oxide of carbon escape from the working channel by the orifices (r) and pass to the condensing chambers (m) and (n). In the chamber (m) the mean temperature is normally about 500°, but below 700°, so that the condensation to the liquid state takes place easily upon its upper wall

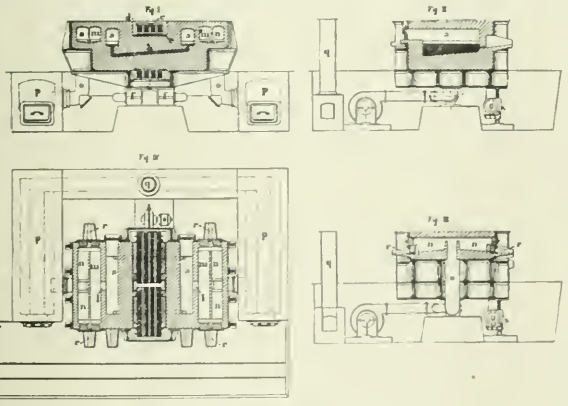


FIG. 2.—ZINC INDUCTION FURNACE

and upon the wall opposite to the point of entrance of the vapors; the uncondensed vapors are finally brought down in the chamber (n). Any zinc oxide and dust carried along by the carbon monoxide pass along into the conduit (o) and are deposited in the dust chambers (p) which connect with a common chimney (q).

When the reduction is finished the condensed zinc is run out by opening the tap hole (r) and inclining the furnace to one side by means of the motor-driven jack-screw (s).

Finally the residues are scraped out of the working door by the use of a metallic rabble.

The heating is not interrupted during the tapping of the zinc or the cleaning out of the residue, so that one-half at least of the furnace is always active.

The circulating induction furnace provides a perfectly closed space in which the heating is effected, and not through a wall or partition as in the present furnace, but by direct contact of the mixture to be reduced with the metal in which the Joule effect is produced. Besides, the mixture with carbon, especially when it contains blende which is conducting, is of itself the seat of the development of electric heat to a not unimportant degree.

It is therefore possible with this electrothermic heating to use distillation capacity as great as one wishes, this capacity being limited only by the power of the electric furnace. At the same time the expense of refractory material is very much reduced, the hand labor is less than in the old furnace with the small muffles, and finally the loss of metal by incomplete reduction, by cracking of retorts, by reoxidation and imperfect condensation, is reduced to a minimum, far below that obtained in a furnace heated by coal or gas.

A large part of the paper contains estimates of the economic value of the process. Mr. Gin first estimates the energy necessary to reduce zinc compounds and finds that in a furnace with a thermal efficiency of 65 per cent the energy required for the reduction of 1 ton of zinc from the oxide is 2,472 kilowatt-hours, from the carbonate 4,330 kilowatt-hours, from the silicate (using lime and carbon) 4,000 kilowatt-hours and from the sulphide (using lime and carbon) 2,965 kilowatt-hours. On account of the high cost of electrical energy it is advisable to previously calcine the ore in order to transform the carbonate of zinc into oxide.

Under the same assumptions as made above Mr. Gin estimates that the energy necessary to reduce one ton of zinc from a calcined calamine is 3,560 kilowatt-hours and from sulphide ore 3,960 kilowatt-hours. He then refers to the treatment of argentiferous sulphides and the application of the process to a complex silver ore.

"For mixed ores, the method of operation may be advantageously modified to utilize the volatility of the sulphides of lead and zinc. The sulphide of lead volatilizes at about 1,000°. In the presence of carbon the sulphide of zinc also volatilizes at about the same temperature. Under the same conditions, the sulphide of iron remains fixed and unaltered. The method of treatment may consist of the following steps: first, separation of the sulphides of lead and zinc, and, second, reduction of the sulphides of lead and zinc."

The first operation may be effected in a Gin circulating induction furnace in which the two working channels are connected with the two condensers.

The ore is mixed with carbon in excess of that required by the following reaction:

$$2ZnS + C = 2Zn + CS_2$$

The mixture of lead sulphide, metallic zinc and sulphide of carbon is led into the condensing chambers, where the reverse reaction to the above takes place, so that now the zinc is resulphurized, and carbon black forms. The mixture of sulphides is collected, lime and carbon are added, and the whole is heated in a similar furnace for the reduction and condensation of the zinc, as previously described. The slag obtained is simple sulphide of calcium. When the reduction is completed in one channel, the zinc is tapped out, the working door opened, and air is admitted, oxidizing superficially the sulphide of calcium to sulphate, increasing its fusibility, and the liquid slag may be easily run out.

The sulphide of silver is volatilized with the other sulphides, except a quite small quantity which is dissolved by the bath of cast iron, and from which it may be regained by treatment of the iron with lead when the iron is sufficiently saturated.

The method of operation may be still further modified by burning the vapors of the sulphides as they issue from the furnace and thus forming sulphates and oxides of lead and zinc, which react one upon the other in such a manner as to produce, in the condenser, part of the lead in the metallic state

containing all the silver, and a mixture of sulphides and oxides of lead and zinc with some basic sulphate of zinc. The oxidized compounds of lead and zinc thus obtained may be taken to the reducing furnace, mixed with lime and carbon, and then reduced.

This oxidation of the products coming from the furnace reduces slightly the energy requirements, and the lime required in the subsequent reduction by some 50 per cent.

Finally Mr. Gin estimates the cost of zinc production from calamine or blende in a large works having ten electric furnaces of 1,000 h.p. each, when hydroelectric power is available. He assumes that with the electric process the profits would be almost double those of the present processes. His final conclusion is as follows:

"The electric furnace processes are clearly superior to present methods. They require less expense for labor and distilling apparatus, the operation is continuous, and the losses are very notably reduced. They permit the direct reduction of sulphide ores and the treatment of complex ores.

"It may be stated, with all certainty, that such countries as Sweden, in which are united in the same region considerable quantities of complex ores with powerful waterfalls, are just suited for the adoption of electrothermic methods.

"The case is similar with the famous ores of Broken Hill, in New South Wales, which may be treated by utilizing the waterfalls of the Blue Mountains or of the Liverpool Chain. They might also be treated in New Zealand, where there are powerful waterfalls.

"The importance of this electrothermic application is emphasized by the fact that there are at Broken Hill, besides the rich ores, nearly 500,000 tons of tailings, containing 100,000 kilograms of silver, 20,000 tons of lead, and 90,000 tons of zinc.

"Similarly, the ores of Tunis, Greece and Sardinia can be advantageously treated by the use of the large water-power available in the French and Italian Alps.

"These examples are not the only ones which could be adduced, but they suffice to prove the immense interest attaching to the subject, and the unquestionably great value of successful electrothermal processes for treating such ores."

In the discussion which followed, Mr. Carl Hering remarked that by the peculiar construction which Mr. Gin has chosen in order to get circulation he invites the "pinch phenomenon." Mr. Woolsey McA. Johnson and Dr. J. W. Richards criticised some special points in the estimates of cost.

Chlorine in Metallurgy.

Mr. Charles E. Baker of Cleveland presented a paper on "A New Application of Chlorine in Metallurgy." Since in the electrolytic production of caustic soda and chlorine from common salt the caustic soda covers more than the cost of the process, the chlorine may be considered to cost nothing. Mr Baker endeavors to use the chlorine for the extraction of metals from refractory ores, described in the paper as sulphides.

The finely pulverized, practically dry ore is placed in a porcelain-lined tube mill provided with lead-lined trunnions, and supplied with flint pebbles. This mill is considered to be necessary for the prosecution of the work. "We know of no other means for completing decomposition, especially in handling zinc sulphides." The chemical action generates so much heat that the chloride formed becomes melted, or volatilized, and spreading to surrounding particles, covers them over as by a varnish, preventing further action by chlorine. As the drum revolves, the flint pebbles grind the particles, presenting continuously fresh surfaces to be acted on. They also tend to break up or prevent any clodding or balling of the mass. The gas is admitted to the drum, and acts at once on the ore. The metal combines with the chlorine, liberating the sulphur.

As the chemical attraction of chlorine is greater than it is for sulphur, sulphur chloride is only formed as the metal contents decrease. The drum revolves during the operation, and chlorination of the metals is effected, leaving sulphur free with the gangue, provided no heat is applied and the supply of chlorine stopped when the metal is chloridized. But if the drum be heated, sulphur chloride is formed, and at about 150° C. is expelled as a gas, and may be condensed. It makes a by-product of much more value than sulphur, being salable at 10 cents per pound.

The process *proper* ends here. We have the chlorides, and the sulphur has been eliminated from its combination, and made available for revenue.

If the process be illustrated as applied to a lead-zinc sulphide ore, carrying gold and silver, the contents of the drum after chlorination would be emptied into leaching tanks, the soluble chlorides removed, leaving behind in the gangue with the free gold any insoluble silver or lead chlorides remaining. In the presence of plenty of other chlorides they are both partly soluble, and in most cases they will be carried forward with the other solutions. During chlorination, the iron forms ferrous chloride, and gold will not become soluble in its presence, nor when chlorine is dry. The gangue, freed from all base metals, and containing the free gold, is in fine condition for gold extraction, much better than if from a roasted ore. It may be recovered by wet chlorination, by cyaniding, or by amalgamation in barrels. It will be too fine for *plate* amalgamation. Silver may be recovered by leaching with sodium hyposulphite. Purification of solution follows. Granulated lead precipitates copper, granulated zinc precipitates lead. The remaining solution would then contain ferrous and zinc chlorides. Chlorine must be supplied to make the iron ferric chloride, then zinc oxide precipitates ferric hydroxid, forming zinc chloride. Electrolysis then produces practically pure zinc, and the chlorine is liberated for use again.

Suppose the ore handled be one whose principal ingredient is copper. It chloridizes as cuprous and cupric salt, either or both. If it should be cuprous, it is then only partially soluble But it is readily soluble in other chlorides, especially of sodium or calcium. Electrolysis then produces copper, liberating chlorine, the iron chloride remaining undecomposed, at the low voltage used in copper electrolysis. No deposit of copper takes place until the cathode department becomes cuprous. In a large plant in Germany where a matte is being handled, the chloride solution contains copper, iron and zinc. Copper and zinc are being produced from the same solution on a large scale, each practically pure. Last year's zinc output averaged about 2¼ cents per pound above the market price for spelter, owing to its purity.

"You are no doubt familiar with the Swinburne-Ashcroft method of handling ores by chlorine under pressure. It produces, by chemical action alone, a temperature of from 600° to 700° C, but is limited in its application to ore carrying not over about 30 per cent gangue, *i. e.*, to concentrated material The difference between their system and this is apparent. Much gangue would block them off mechanically, while we prefer having the gangue to keep down the temperature, to avoid volatilizing the chlorides. In their case sulphur vaporizes."

"Here is an illustration of an application of chlorine in the form of hydrochloric acid as the chloridizing agent. The silicate of nickel-aluminium-magnesium-iron, forming the garnierite ore found in New Caledonia, presents an almost impossible smelting proposition, as the main ingredient is magnesia. It can readily be handled by hydrochloric acid, and, after chloridizing, the acid is recovered from the base metal chlorides by calcination and used again, the nickel only retaining chlorine. We worked this process out to apply on a similar ore, found in North Carolina, and it will also apply to another deposit found in Oregon.

"The calcination of the chloridized silicate drives off the hydrochloric acid, and at the same time renders the gangue granular and readily leachable. This is an application to an ore carrying only about 1¼ per cent nickel with 15 to 25 per

cent magnesia. Smelting such would be impossible, yet the expense was light, because the consumption of hydrochloric acid was, in the end, limited almost to the requirement of the nickel for its chloride. From the nickel chloride so formed we produced metallic nickel electrolytically, recovering the chlorine. No smelting at any stage.

"In commercial practice, it will be found that 2 kilowatt-hours will produce about 1 pound of chlorine, zinc, iron or nickel, and about .4 pounds of copper or lead. In the case of lead, these figures are derived from the electrolysis of the fused chloride, where some of the energy was used to maintain fusion.

"It might be proper to name some of the advantages of this method as compared with smelting. Roasting is avoided, with its expensive furnaces and suits for damages from the poisonous gases evolved. Concentration is avoided, with its expensive machinery and power requirement, and with its losses of 15 to 20 per cent of the values. The sulphur is recoverable for market. Volatilization and slagging losses do not occur. Any refractory ore can be rendered free milling, with the sulphur so thoroughly eliminated that the per cent of extraction would very high. In the case of tellurides, tellurium chloride goes into solution and is leached away, leaving the gold free in the clean gangue.

"In nickel-cobalt ore, the cobalt can be precipitated as a hydroxide from its chloride as a step preceding the nickel electrolysis. Its advantage in handling the cobalt-nickel arsenides of Canada is apparent. At present, mine owners get little beyond a reduced proportion of the silver content, but the arsenic and antimony should be saved as commercial products."

Electrolytic Reduction of Nitric Acid.

A paper by Dr. Harrison E. Patten, of the Bureau of Soils, Washington, dealt with the electrolytic reduction of nitric acid, studied mainly from the standpoint of the yield of ammonia.

In order to get a view of the initial electrode potential in the solution, single potential measurements were made, using different metallic cathodes. These, together with the decomposition voltage measurements of Flaschner, help to give an insight into the reactions which may be expected under actual conditions of electrolysis.

A series of experiments, using a copper cathode with a porous cup diaphragm and lead anode in dilute sulphuric acid, was first made to ascertain the effect of the concentration of sulphuric acid upon the yield of ammonia and of hydroxylamine, discharge potentials being taken at the cathode during the process of electrolysis. The results confirmed those of the earlier investigators to the effect that the yield of ammonia increases with the concentration of sulphuric acid, while the yield of hydroxylamine decreases.

The effect of current density upon the yield of ammonia and of hydroxylamine at a copper cathode was then determined, using a porous cup diaphragm for the cathode chamber, the anode being lead in dilute sulphuric acid. Here also cathode discharge potentials were taken. The results show that increase of current density decreases the yield of ammonia at a copper cathode, while when using a platinum cathode, the reverse is true.

The effect of temperature upon the yield of ammonia and of hydroxylamine at a copper cathode, was found to be so slight as to render rigid temperature control in the experiments carried out unnecessary

The effect of dissolved copper upon the yield of ammonia at the copper cathode and at an amalgamated copper cathode was next studied, and for comparison experiments were made with no copper sulphate present, using on the one hand a pure copper cathode, and on the other hand a pure mercury cathode. It was found that the yield of ammonia is very greatly increased by the continual deposition of copper at the cathode. The suggestion made by Tafel that this effect is due to a cathalytic action of the deposited spongy copper, is open to question, since this same effect is produced when the copper is in similar manner continually deposited upon the amalgamated copper cathode, whose surface remains smooth throughout the reduction. These experiments have a very interesting bearing upon the theory of the "nascent state." There is a maximum point for this effect. Thus, when nitric acid is reduced at a copper cathode in a solution very highly concentrated with respect to copper sulphate, the yield of ammonia is less than is obtained with more dilute solutions. This same effect was obtained by Ingham.

The results of former investigators upon the effect of the cathode metal in determining the yield of ammonia and of hydroxylamine in the reduction of nitric acid have been confirmed by the author, and in addition it is shown that a low cathode discharge accompanies a high yield of ammonia when the current density is the same. Further, several reductions were made in alkaline solutions and the anode and cathode discharges taken, together with the yield of ammonia, for platinum, zinc and copper cathodes, using a small platinum anode.

To ascertain whether nitrogen or nitrogen oxides may be liberated at platinum anode and copper cathode during the electrolysis of potassium nitrate in the presence of sulphuric acid and copper sulphate, the anode and cathode gases were collected and analyzed, and the discharge potentials read from time to time during the electrolysis. It was found that nitrogen, either as free nitrogen or in the form of oxides, was given off at both the copper cathode and the platinum anode.

To test the definite statements of Tafel and others that hydroxylamine is not reducible at a copper cathode, hydroxylamine hydrochloride was electrolyzed in 1.7 per cent sulphuric acid solution at a copper cathode and 58.8 per cent of the total nitrogen recovered as ammonia; in similar manner with copper sulphate present in the solution, 65.3 per cent of the total nitrogen in hydroxylamine was converted to ammonia. These experiments, together with those of Flaschner, recently published, make it evident that the reduction of nitric acid to ammonia at a copper cathode may, and probably does, go through the hydroxylamine stage.

Finally it was shown that electrolysis of sodium nitrite at a copper cathode in sulphuric acid solution reduces all of the nitrogen to a form not oxidizable by potassium permanganate. Fifty-nine per cent of the total nitrogen present as nitrite was converted to ammonia and recovered.

Determination of Copper.

A paper by Mr. E. E. Free, of the Agricultural Experiment Station in Tucson, Ariz., dealt with the determination of minute quantities of copper. The determination of quantities of copper less than 1 milligram cannot be carried out by the ordinary procedure of electrolytic analysis, because of the impossibility of weighing with sufficient accuracy the dishes or other cathodes usually employed. Phelps avoids this difficulty by precipitating the copper electrolytically, dissolving the deposit and estimating it colorimetrically. By the use, however, of the electrode described by the author the colorimetric determination may be dispensed with and the copper weighed directly as deposited, a fair degree of accuracy being obtainable with quantities of copper as small as .05 milligram.

Fig. 3. Electrode.

The electrode is made from a small piece of platinum wire bent into a spiral with one end extending along its axis. It is supported in the bath by wrapping this free end four or five times about a hook of heavy platinum wire. If the hook be straight and slightly tapered toward the point the electrode may be easily attached and removed and makes perfect contact with the hook. The whole arrangement is shown

in Fig. 3. The electrode used by the author weighed about 0.3 gram.

The extraction and concentration of the copper are carried out by the usual methods. The electrolysis may be made in either nitric or sulphuric acid solution, low currents being used on account of the small cathode area. The author uses 2 per cent to 4 per cent nitric acid and a few drops of sulphuric acid in about 25 c.c. solution and electrolyzes over night with about 1.8 volts and 0.01 ampere. The containing dish serves as anode.

Boiling Points of Metals.

A paper by Dr. Oliver P. Watts dealt with "the metals in order of their boiling points as arranged from Moissan's experiments in the distillation of metals and alloys."

The widespread introduction of the pyrometer into both scientific and technical metallurgy has resulted in an increase in the accuracy and extent of our knowledge of the melting points of the metals. Their boiling points, however, are still an almost unknown quantity. A knowledge of the latter is of importance to the experimenter with the electric furnace, for in the production of metals from their ores the boiling point of the metal fixes the maximum temperature of the furnace, consistent with a good yield.

Although it would be most satisfactory to have the boiling points of the metals expressed in degrees centigrade (or Fahrenheit), it is not necessary that they be so stated in order to be of service in electric furnace work. An arrangement in order of their boiling points, with some indication of the magnitude of the intervals between successive members of the series, would be of practical use.

Dr. Watts gives a concise summary of the various determinations made by Moissan, and finally presents his attempt to arrange the entire series of metals treated in order of their boiling points. "This is a difficult task to accomplish satisfactorily, and probably an impossible one to carry out with complete accuracy. In several cases the difference between the weights of two metals distilled is within the limit of experimental error. The specific heats and unknown latent heats of vaporization may also cause errors in the tabulation, as the writer could not make allowance for these factors. The only known points in the series are the boiling points of zinc, 940° C., and copper, 2,100° C., as determined by Féry. The boiling point of tungsten was then assumed to be 3,700° C., and the other metals were arranged between these limits.

"The number standing opposite each metal is not claimed to be its boiling point, but only as an indication of its relative position in the series which begins with zinc at 940° C., and ends with tungsten at some unknown temperature above the melting point (3,200° C.).

Zinc	940° C.	Titanium	2,700° C.
Cadmium	1,025	Rhodium	2,750
Lead	1,250	Ruthenium	2,780
Silver	1,850	Gold	2,800
Copper	2,100	Palladium	2,820
Tin	2,170	Iridium	2,850
Manganese	2,200	Osmium	2,950
Nickel	2,450	Uranium	3,100
Chromium	2,500	Molybdenum	3,350
Iron	2,600	Tungsten	3,700
Platinum	2,650		

"The order for the first six metals with reference to each other is correct, since it was obtained from the distillation of alloys. The position of manganese with reference to tin and copper is doubtful. Gold is surprisingly high in the series, and if correctly placed, is second only to tin in the wide range of temperature of its liquid state. Further and more conclusive experiments may lower the position of gold. Moissan's experiments show that there is considerable vaporization of titanium before it melts, but even so, the low position here necessarily assigned for its boiling point must be a surprise to anyone who has tried to fuse this extremely refractory metal. The writer thinks that further experiments, particularly in the absence of air, may greatly change the place of titanium."

In the brief discussion which followed Dr. J. W. Richards remarked that in making use of the determinations of Moissan one should take into consideration that the metals were distilled from alloys and not from pure metals.

Granular Carbon Resistors.

A paper on this subject by Messrs. S. A. Tucker, A. Doty and R. W. Cauchois was presented by Prof. Tucker. In the use of granular carbon for resistance material in the electric furnace many varying conditions may exist, dependent on the size of the carbon grain, the compression to which the grains are subjected and the number of times the material has been employed as resistor.

It has always been noticed in using an electric resistance furnace that at the beginning of the run with new ground coke as resistor, although a high e. m. f. is impressed across the terminals of the furnace, yet the current is small on account of the high resistance of the "green" resistor material. After a little while the temperature of the furnace rises and a large quantity of gas and fumes is given off by the resistor. (In one of the experiments of the authors, using direct current, the smoke appeared first at the positive terminal, then in the center of the resistor, and finally at the negative terminal.)

This condition of gas evolution prevails for some time while the resistance of the furnace and the current vary very rapidly. If a sufficiently high e. m. f. is impressed on the terminals of the furnace and maintained constant, the temperatures will steadily rise until this period of gas evolution is passed and the rapid fluctuations of the resistance cease. It will then be found that as the temperature increases the resistance slowly but steadily decreases, and if the impressed e. m. f. is not rapidly cut down a large rush of current is liable to occur.

If, however, the resistor has been previously subjected to one thorough heating run, in which a high temperature in the carbon has been obtained, so that the volatile products are eliminated from the coke, the conditions existing in using the same material afterwards as resistor are far more uniform. In constant-voltage experiments of the authors it was found that when in this case the temperature rises the resistance first decreases to a minimum, then remains constant for a while and finally increases with increasing temperature.

The authors experimented with various grades of coke, passing a series of sieves of 10, 20, 30, 40 and 50 meshes to the inch, and also with a mixture of these grades. In their first experiments the authors used direct current and tested both green coke and preheated coke with variable direct current. Their next tests were made with variable alternating currents, but the results of the two sets of tests with direct and alternating current are not comparable. In order to make a definite comparison possible a series of constant-current tests were made, both with direct current and alternating current.

A comparison of watthours required to reach a temperature of about 340° with alternating current and with direct current is as follows:

Alternating Current.		*Direct Current.*	
Watthours.	*Grade of Coke.*	*Watthours.*	*Grade of Coke.*
38	50-mesh.	46	50-mesh.
35	20-mesh.	230	20-mesh.

A set of experiments was made in which an external pressure was exerted on the granular coke. The only change caused by pressure is a considerable decrease of the resistance of the coke.

While the results of the authors are given in great many diagrams and tables, the following general conclusions may be drawn from them. The results obtained seem still to leave it an open question whether a resistor material of high or low

resistance would give the most efficient results. In fact, the design of the furnace might decide this question, or whether the machine furnishing the energy was designed for low voltage and heavy currents or vice versa.

From the tests of the authors, using variable direct current, the conclusion might be drawn that a certain grade of coke was more efficient than another, but other tests made with constant current contradict these results. Also the comparative tests with direct and alternating current would mean to indicate that a greater efficiency is obtainable with alternating than with direct current.

Further, it appears that the more frequently the coke is used the lower is the temperature which may be attained by the same expenditure of energy.

Finally, the coarser the grade of coke the greater is its conductivity; and any single grade of coke is more efficient than a mixture of all grades.

The paper was briefly discussed by Dr. J. W. Richards and Mr. Carl Hering.

The Heat Conductivity of Carbon.

A paper by Mr. F. A. J. FitzGerald discussed the comparative heat conductivities of carbon and graphite. These figures are of great importance for electric furnace work.

All electric furnaces receive their electrical energy from the outside, and with the single exception of the electric induction furnace, to which energy is supplied by means of electromagnetic induction, the current is introduced through terminals. Formerly amorphous carbon electrodes were generally used, but since Mr. Acheson succeeded in making artificial graphite electrodes of suitable form for electric furnace work, these graphite electrodes have found very extended application. One of their greatest advantages is the great facility of machining them into any shape. Another advantage is their much higher electric conductivity, so that it is possible to increase very much the current density for the same Joulean losses within the electrodes as compared with amorphous carbon electrodes.

In making calculations of this sort, it is, however, important to take into consideration that artificial graphite electrodes also have a much greater thermal conductivity than carbon electrodes, so that the heat loss from the interior of the furnace to the outside is increased. Mr. FitzGerald's experiments on this matter show that artificial graphite has a heat conductivity of 18 or 18½ times that of amorphous carbon.

The paper was briefly discussed by various speakers, and Mr Carl Hering referred to the fact that if one has a metal rod with a crack in it, it is possible to heat the end of the rod on one side of the crack up to red heat while the other end remains relatively cool. The crack has by no means such an effect on the electric conductance of the rod as on the thermal conductance. Something of this kind could be made use of in graphite electrodes to diminish the loss of heat.

Silver Coulometer.

"Studies on the Silver Coulometer" was the title of an elaborate paper by Dr. L. H. Duschak and Dr. G. A. Hulett of Princeton University. The paper was presented in abstract by Dr. Duschak.

Parallel with the work on standard cells, the authors have undertaken a determination of the electrochemical equivalent of silver, investigating the porous-cup coulometer proposed by Dr. T. W. Richards as to its reproducibility, the purity of the silver deposited and the nature of the reactions at the cathode.

Particular attention has been given to the question of weighing and a number of manipulation tests and blank experiments have been carried out in order to determine the errors and their distribution. The coulometers, as the authors used them, showed a reproducibility of one in 200,000 when the silver was deposited on platinum. With deposits on silver the results were not as good.

The question of the purity of the deposited silver has received particular attention and a method has been devised by which it has been possible to remove and directly determine the impurities instead of determining them by difference as heretofore. The silver deposit was readily detached from the cathode cup (platinum) with a spatula and brought into a vacuum apparatus which was provided with a manometer. It was found that the thoroughly dried silver gave off water and gases in vacuo. The water was condensed in a little side tube by the application of a freezing mixture and this tube sealed off and the contents determined. The volume and pressure of the remaining gases (oxygen and nitrogen) were determined.

It was found that the cathode silver from a silver nitrate solution began to give off water and gases at about 160° and on increasing the temperature more were given off. Even at 600° the silver still retained water and gases which were not all removed until the metal was melted. The total amount was small, about one part in 10,000, but they were determined for the first time directly and the method gives the qualitative and quantitative information to be taken into account in an accurate determination of the electrochemical equivalent of silver.

It was also found that the silver deposited from an air-free solution of silver nitrate weighed less than the corresponding deposit from an air-saturated solution and that this vacuum deposit also contained correspondingly less impurities.

It will also be necessary to know whether the current at the cathode is doing any other work than depositing normal univalent silver ions, and this question is now receiving the attention of the authors.

In the discussion which followed Mr. Carl Hering suggested that if platinum is used as electrode material occluded gases may have an effect and that gold may be preferable. Dr Hulett replied that they are now making experiments with a gold electrode.

Concentration Cells.

A paper by Prof. Henry S. Carhart and Mr. F. J. Mellencamp was a further contribution to the study of concentration cells. If the well-known Gibbs-Helmholtz equation, which is valid for any reversible galvanic cell or electrolytic process, is applied to the special case of concentration cells, and if we further assume that the solutions used are very dilute, so that the heat of dilution is negligible, we find that the e. m. f. of the concentration cell is given by the second term of the Gibbs-Helmholtz equation, and therefore equals the absolute temperature multiplied with the temperature coefficient of the e. m. f.

If, however, the heat of dilution is not negligible the first term of the Helmholtz equation must also be considered. Whenever the heats of dilution (reckoned from any standard concentration) of the two solutions in the two legs of the cell differ, this difference is available as energy to produce an e. m. f. represented by the first term of the Helmholtz equation. If then the temperature coefficient of the cell is positive, the e. m. f., due to a positive resultant heat of dilution, is to be added to the value of $T\,dE/dT$.

The authors have applied this principle to several concentration cells for which the heat of dilution was known. The electrolytes in the different cells were zinc sulphate cadmium sulphate, copper sulphate and zinc chloride. The agreement between theory and experiment is remarkably good. For instance, in the case of a concentration cell consisting of $ZnCl_2 . 21.9H_2O$ and $ZnCl_2 . 386H_2O$ the free energy, due to the difference of heat of dilution, represents the e. m. f. of 1.1060 volt. The temperature coefficient of the e. m. f. is negative in this case, and the product of the temperature coefficient by the absolute temperature gives −0.0289 volt. Therefore, according to the Gibbs-Helmholtz equation the e. m. f. should be 0.0720, while 0.0751 was found by measurement. In all the other cases dealt with by the authors the temperature coefficient is positive.

Radioactivity.

A paper by Dr HERMAN SCHLUNDT dealt with the electroscopic determination of the radium present in some tufa deposits from Hot Springs, Ark. Dr. Boltwood has formerly examined the waters of these springs for radioactive properties, and found that they possess radioactivity which was due to the presence of radium emanation. Considerable variations were found in the activity of the different water samples, whose mineral constituents stand in close resemblance. No connection could be established between chemical composition of the waters and the striking differences observed in their radioactive properties. Dr. Schlundt has determined the quantities of radium present in several tufa samples from Hot Springs. The quantities found in some of the samples greatly exceed the quantity found in the particular sample tested by Dr. Boltwood. Such marked variations as the latter found in the quantities of radium emanation present in the water samples were likewise exhibited in the tufa samples examined.

Deflocculated Graphite.

Mr. EDWARD G. ACHESON, of Niagara Falls, presented a lecture on this subject with demonstrations and experiments.

In 1901 Mr. Acheson made a series of experiments to produce crucibles from artificial graphite. This led him to a study of clays. He found that American manufacturers of graphite crucibles imported from Germany the clay used by the same clays are when found as sedimentary clays at a distance from their place of origin.

Mr. Acheson concluded that the greater plasticity and the tensile strength were developed during the period of transportation from the place of their formation to their final bed, and thought it might be due to the presence of extracts from vegetation being in the waters which carried them. He, therefore, made several experiments on clay with vegetable extracts, tannin being one of them, and found that a moderately plastic, weak clay, when treated with a dilute solution of gallotannic acid or extract of straw, was increased in plasticity, required about half as much water to produce a given degree of fluidity, was caused to remain suspended in water, and was rendered so finely subdivided that it would pass through a fine filter-paper. On account of the story in the Bible of how the Egyptians had the children of Israel use straw in the making of bricks (the straw being used, in Mr. Acheson's opinion, not for any benefits derivable from the weak fibres but for the extract) he called clay so treated Egyptianized clay.

Mr. Acheson then referred to his more recent discovery of a process for producing fine, pure unctous graphite (see our Vol. IV, p. 502). When he began to work out the details of its application as a lubricant, he found that in the dry form or mixed with grease or oil, it was easy to handle, but Mr. Acheson wished it to enter the entire field of lubrication as occupied by oil. In his first efforts to suspend it in oil he met

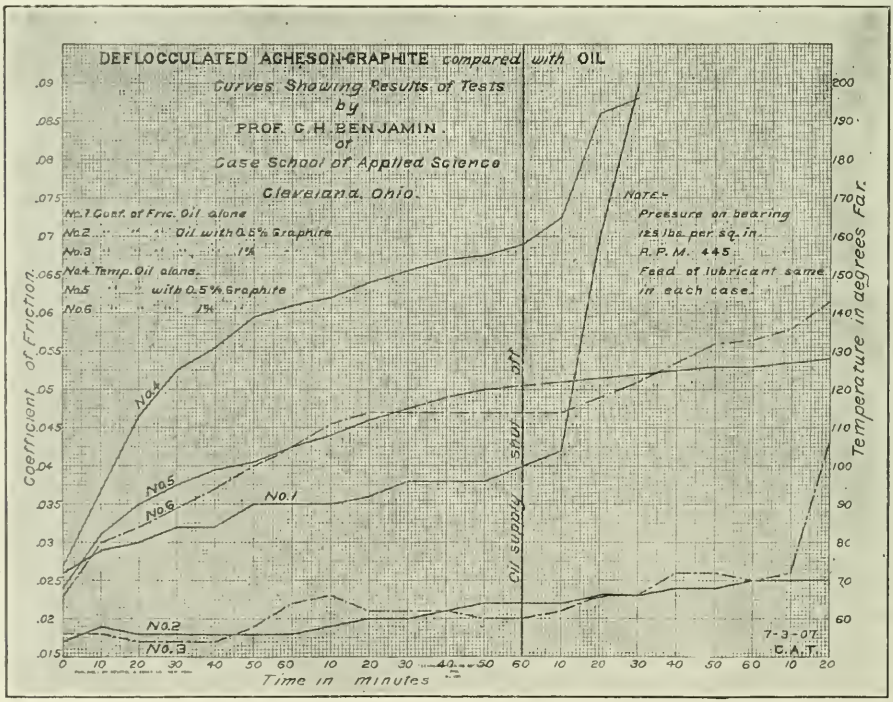


FIG. 4.—COMPARATIVE TESTS OF OIL AND OF OIL AND DEFLOCCULATED GRAPHITE AS LUBRICANT.

them as a binder of the graphite entering into the crucibles. The reason is that the German clays are much more plastic and have a greater tensile strength than American clays of similar chemical composition. Chemical analysis did not give any explanation of the difference. Moreover, residual clays—those found at or near the point at which the parent feldspathic rock was decomposed—are not as plastic or strong as the same troubles encountered before by others, the graphite would quickly settle out of the oil. Then it occurred to him that tannin might have the same effect on graphite that it had on clay. He tried it with satisfactory results.

Mr. Acheson then made various experiments to show this effect. In one experiment he took two equal quantities of unctous graphite as produced in the electrical furnace. When

in this form he calls it disintegrated unctous graphite. To one sample he added plain water, and, after rubbing up in a mortar, he poured it into a test tube. To the other sample he added water, a little gallotannic acid and a few drops of ammonia. The ammonia is not always necessary, but improves the results with some waters. He then rubbed the mixture in the mortar as in the first case and poured into a test tube. When both tubes were shaken and then set to rest to settle, it took only a few minutes until the graphite in the plain water had completely separated from the water; on the other hand, the mixture of water, tannin, and ammonia remained black when shaken up. As a matter of fact it remains so indefinitely, and even more, the result is much improved by time.

The graphite is here in what Mr. Acheson calls the "deflocculated" condition, a condition of fineness beyond that attainable by mechanical means, a "condition approaching the molecular state." It is usual to call this condition the colloidal state. The graphite is so fine as to pass with ease through the finest filter-paper. This was shown by an experiment.

In a further experiment, Mr. Acheson introduced a few drops of hydrochloric acid into the black colloidal deflocculated graphite fluid and then slightly warmed it over spirit-lamp flame. This causes the suspended graphite to flocculate so that when the liquid is then poured onto a second filter paper, the water runs through clear, the graphite remaining on the paper. This is the well-known effect of electrolytes on colloids.

Mr. Acheson has successfully used deflocculated graphite in water instead of oil in drop-feed oilers and with chain-feed oilers. He has a shaft in his laboratory 2 5/16 inches in diameter, revolving at 3,000 revolutions per minute in a bearing 10 inches long that had no oil on it for months, deflocculated graphite in water being the only lubricant used, the feed being by chain, and it ran perfectly. On the same shaft is a similar bearing lubricated with oil; this runs much the warmer of the two.

Mr. Acheson said that a few days after this test was started a pessimistic friend of his remarked that just plain simple water might give the same results, that the presence of graphite might be unnecessary. "We are influenced by the opinions of others even when we know or think they are wrong," so Mr. Acheson emptied the oil out of the second bearing on the shaft and substituted plain water. The results during the first 12 hours seemed to support the contention of his friend. The next day after the machine had stood motionless over night things did not look so rosy for the water; it was a lame second on account of rust, and was hurriedly removed. Mr. Acheson will not recommend clear water as a permanent lubricant.

Deflocculated graphite in water possesses the remarkable power of preventing rust or corrosion of iron or steel. This graphite, even after flocculation, is so fine in its particles that when dried *en masse* it forms a hard article.

While deflocculated graphite in water is an efficient lubricant, it has the drawback of losing its water by evaporation Mr. Acheson also appreciated that much time would be consumed in converting the world to water lubrication from the present one of oil. Therefore, he set before him the problem of replacing the water medium with oil. A very great deal of difficulty and many discouraging conditions were met with, but success was finally achieved and it has been found that about ½ per cent of deflocculated graphite in oil is sufficient for most work.

Mr. Acheson showed in a diagram the results of tests made by Prof. G. H. Benjamin at the Case School of Science with oil alone and with oil and deflocculated graphite The curves are shown in Fig. 4, and are almost self explanatory

It will be seen that the initial friction of oil and 0.5 per cent graphite was 65 per cent of that of oil alone After 60 minutes the friction of graphite-oil was 55 per cent of oil alone. While the friction of oil alone increased in this time by 54 per cent, the friction of oil and graphite increased 30 per cent only. After lubrication was shut off the friction of oil alone increased 125 per cent in 30 minutes, while that of oil and graphite increased only 14 per cent in 80 minutes Spindle oil was used in all tests Curves 1, 2, 3 are the friction curves, 4, 5, 6 the temperature curves.

After the conclusion of the lecture, Mr. John Rhodin, the well-known English electrochemist, paid a high compliment to Mr. Acheson by saying that it is the Acheson electrodes which have made commercial electrochemistry possible.

Dr. H. N. Potter remarked that he had used deflocculated graphite in oil as lubricant on his automobile, and that the consumption of the lubricant has thereby been reduced to one-half.

Diamond and Moissanite—Natural, Artificial and Meteoric.

The long address presented by Dr. George F. Kunz, the well-known gem expert of Tiffany & Co., dealt with all phases of this subject and was illustrated by numerous lantern slides and exhibits. The author discussed the properties and uses of natural diamonds varying from those exceedingly valuable as precious gems to those so useful for industrial work in diamond drills. He then discussed Moissan's well-known experiments on the production of diamonds in the electric furnace. Concerning meteoric diamonds, he mentioned the renowned block of meteoric iron from Canyon Diablo, Arizona, which was found to be somewhat heterogeneous in its structure and to contain iron, nickel, sulphur phosphorus, silicon and carbon. The latter element was found to exist in its several forms—amorphous carbon, graphite and diamond, and Moissan succeeded in separating both the black and the transparent variety of the diamond.

In connection with these, Moissan discovered, as absolutely new, green hexagonal crystals of carbon silicide. This is the same substance which is so well known under the name of carborundum, and is artificially produced in very large quantities in the electric furnace. As this is the first instance in which carbon silicide has been proved to occur in nature, and, therefore, as a mineral, it is entitled to a distinct mineralogical name, and Dr. Kunz has thought it fit to associate Moissan's name with it and call it Moissanite. Moissanite is therefore natural carborundum, or carborundum is artificial moissanite.

Other Papers.

The concluding lecture of the Saturday meeting was presented by Dr. A. S. Cushman, of Washington, D. C., on the corrosion of iron as an electrochemical phenomenon. The paper gave a summary of his researches which have already been covered in full in our July issue, pages 254 and 257, and in our September issue pages 343 and 364 Dr Cushman also exhibited several of his samples of steel on which the anodic and cathodic zones had been made visible in different colors by means of his special inventor As some one remarked, "Dr Cushman has succeeded in putting the theory into evidence in our national colors."

The following papers were either presented very briefly in abstract or read by title only

Physico-Chemical Notes on the Alkali Aluminates By P. B. Sattler

Action of Ammonium Persulphates on Metals By J. W. Turrentine.

Note on the Use of the Capillary Electrometer for Alternating Voltages By M. G. Flowa

Electrolytic Separation of Silver and Copper. By H. W. Gillette.

The Treatment of Storage Battery Elements Before Putting Them Out of Commission By O. W. Brown and R. R. Sayers.

On the Nature of Electrolytic Conduction By I. Kahlenberg.

* * * *

Among the guests from abroad who attended the meeting we noticed Mr John Rhodin, the well known Swedish electro-

chemist, who is now making his home in England. He is probably best known through his mercury cathode cell.

As guests of Mr. Jacob Hasslacher, Count and Countess Andre de Riva-Berni, of Paris, and Mr. Bernard Dräger, of Lubeck, Germany, were present at the banquet. Count de Riva-Berni is the general manager of the Comptoir International de vente du Ferro-Silicium; *i.e.*, the European ferro-silicon syndicate. Mr. Drager is part owner of the Drägerwerke, of Lübeck, which make a specialty of the use of oxygen for sanitary and industrial purposes (autogenous welding, autogenous cutting of steel plates, etc.).

* * * *

The following is a complete alphabetical list of all members and guests who registered at the meeting. Where no place of residence is given New York City is meant:

Mr. H. Abraham, Bound Brook, N. J.; Mr. and Mrs. E. G. Acheson, Niagara Falls, N. Y.; Mr. Charles E. Acker; Mr. and Mrs. Lawrence Addicks, Elizabeth, N. J.; Mr. A. B. Albro; Mrs. H. Aledambra; Mr. Jerome Alexander; Mr. A. Appelberg, Schenectady, N. Y.; Mr. Clement B. Asbury, Brooklyn, N. Y.; Dr. Leo Baekeland, Yonkers, N. Y.; Mr. A. R. Baker; Mr. Charles E. Baker, Cleveland, Ohio; Mr. E. T. Baker, Brooklyn, N. Y.; Mr. H. B. Baldwin, Newark, N. J.; Mr. D. A. Bartlett; Prof. and Mrs. C. F. Baskerville; Mr. Howard G. Bayles; Mr. F. M. Becket, Niagara Falls, N. Y.; Mr. W. B. Bishop, Brooklyn, N. Y.; Mr. F. W. Blair; Miss Katharine Blunt, Brooklyn, N. Y.; Mr. P. A. Boeck; Mr. W. D. Bonner, Princeton, N. J.; Dr. W. Bowman; Mr. George M. Boynton; Mr. C. S. Bradley; Mr. W. E. Bradley; Mr. G. Breed, Philadelphia, Pa.; Mr. F. E. Breithut; Dr. A. A. Breneman; Prof. W. H. Bristol; Mr. P. S. Brown; Mr. Wm. Hand Browne, Jr.; Mr. Irwin Buck; Mr. L. Buck; Mr. A. W. Buel; Mr. S. C. Buel; Prof. C. F. Burgess, Madison, Wis.; Mr. H. M. Burkey, Newark, N. J.; Miss M. C. Burnley, Poughkeepsie, N. Y.; Mr. Thomas Callahan, Mr. Roland Calverla; Dr. H. R. Carveth, Niagara Falls, N. Y.; Mr. C. R. Cary, Philadelphia, Pa.; Dr. W. R. Cathcart, Maywood, N. J.; Mr. G. F. Catlett; Mr. Hardee Chambliss, Brooklyn, N. Y.; Prof. and Mrs. Charles F. Chandler; Mr. Camille Cito, Newark, N. J.; Mr. A. N. Clark; Mr. W. G. Clark; Mr. E. B. Cobb; Mr. H. R. Cobleigh; Mr. H. V. Coes; Mr. H. B. Coho; Mr. E. A. Colby, Newark, N. J.; Mr. H. D. Cowles; Mr. J. S. Crider, Cleveland, Ohio; Prof. F. B. Crocker; Mr. Wm. D. Crumtin, East Orange, N. J.; Mr. Robert W. Curtis; Mr. Robert W. Davis, Jr., Haskell, N. J.; Mr. A. E. Dean; Mr. F. A. Decker, Philadelphia, Pa.; Mr. J. M. Deshong; Mr. W. A. Doerflinger, Brooklyn, N. Y.; Prof. and Mrs. Charles A. Doremus; Miss M. Dorn, Poughkeepsie, N. Y.; Mr. B. Dräger, Lübeck, Germany; Dr. W. Dreyfus; Dr. and Mrs. G Drobegg, Brooklyn, N. Y.; Mr. E. Durant; Mr. Myron C. Durkee; Mrs. G. Durkyee; Dr. L. H. Duschak, Princeton, N. J.; Mr. T. A. Edison, Orange, N. J.; Dr. A. H. Elliott; Mr. H. H. Emrich, Maurer, N. J.; Mr. Charles Engelhard; Mr. H. Engle, Roanoke, Va.; Mr. Timothy P. Epps; Miss F. M. Eschenberg, Poughkeepsie, N. Y.; Mr. G. S. Ettla, Roanoke, Va.; Mr. Ernest Fahrig, Philadelphia, Pa.; Mr. J. M. Finch, New Rochelle, N. Y.; Dr. C. G. Fink, Schenectady, N. Y.; Mr. E. M. Fischer, Paris, France; Mr. C. M. Fitz Gerald; Mr. F. A. J. Fitz Gerald, Niagara Falls, N. Y.; Mr. R. Fleming, Lynn, Mass.; Mr. Alfred D. Flinn; Dr. R. von Foregger; Mrs. M. L. Foster; Mr. O. R. Foster, Brooklyn, N. Y.; Mr. C. F. Fowler; Dr. Franklin; Mr. Edward E. Free, Washington, D. C.; Miss E. M. Freeman, Poughkeepsie, N. Y.; Mr. R. H. Gaines; Mr. W. C. Geer, Akron, Ohio; Mr. W. U. Gillespie; Mrs. F. X. Gower, Oswego, N. Y.; Mr. F. Gowers, Oswego, N. Y.; Miss Mary Green; Mr. A. E. Greene, Heroult-on-the-Pit, Cal.; Mr. H. C. Griffin; Mr. A. E. Grip, Brooklyn, N. Y.; Mr. Geo. G. Grover, Ansonia, Conn.; Miss C. M. Guion, Poughkeepsie, N. Y.; Mr. Leo. F. Guttman; Dr. B. F. Halvorson, Kristiania, Norway; Miss H. Hamer, Manchester, England; Mr. W. J. Hammer; Mrs. J. Hampson, Ashton, England; Mr. William J. Hancock, Brooklyn, N. Y.; Mr. W. A. Harnor; Dr. E. I. Harrington, Yonkers, N. Y.; Mr. Martin Hedlund, Niagara Falls, N. Y.; Mr. F. C. R. Hemingway; Mr. and Mrs. C. I. B. Henning, Haskell, N. J.; Mr. Carl Hering, Philadelphia, Pa.; Mr. A. C. Higgins, Worcester, Mass.; Mr. W. E. Hilland, East Orange, N. J.; Dr. and Mrs. E. O. Hovey; Mr. and Mrs. Henry Howard, Brookline, Mass.; Mr. G. M. Howell, Philadelphia, Pa.; Dr. W. S. Howell; Miss A. C. Hughes; Dr. Geo. A. Hulett; Mr. W. R. Hullbert; Mr. W. F. Hurlbut; Mr. F. S. Hyde, Brooklyn, N. Y.; Mr. George Iles; Mr. and Mrs. W. R. Ingalls; Mr. and Mrs. Alois von Isakovics, Monticello, N. Y.; Mr. J. P. Irwin; Mr. H. A. Jackson, Wilmington, Del.; Mr. W. McA. Johnson, Hartford, Conn.; Mr. R. Compton Jones; Mr. C. M. Joyce, Arlington, N. J.; Dr. Edward Keller, Perth Amboy, N. J.; Mr. V. P. Krauss; Miss Bessie Kunz; Dr. and Mrs. George F. Kunz; Mr. G. H. Kunz; Mr. E. F. Lake; Mr. A. B. Lamb; Mr. I. Langmuir, Hoboken, N. J.; Mr. Arthur B. Larcbar, Old Town, Maine; Mr. E. G. Lavino, Philadelphia, Pa.; Mr. E. J. Lavino, Philadelphia, Pa.; Mr. A. Lebrecht; Mr. T. Le Clear; Mr. W. G. Levison, Brooklyn, N. Y.; Dr. Morris Loeb; Mr. Horatio Loomis; Mr. A. V. Luther, South Orange, N. J.; Mr. Frank S. MacGregor, Hyde Park, Mass.; Mr. J. L. Mack, Nazareth, Pa.; Mr. Frederick Maeulen, Mount Vernon, N. Y.; Mr. C. O. Mailloux; Mr. H. T. Matthew; Mr. and Mrs. L. H. Maxim, Landing, N. J.; Mr. J. Y. McConnell, Colwyn, Pa.; Dr. Chas. F. McKenna; Mr. J. McLean, Brooklyn, N. Y.; Dr. W. McMurtrie; Mr. Sidney A. B. Meakin, Schenectady, N. Y.; Mr. Reginald Meeks; Mr. Bannista Merwin; Mr. John Meyer, Philadelphia, Pa.; Mr. H. S. Miner, Gloucester, N. J.; Mr. H. R. Moody; Mr. and Mrs. J. T. Morehead; Mr. Charles W. Moulton, Poughkeepsie, N. Y.; Mr. Charles J. Mullaly; Mr. C. I. Murphy, Haskell, N. J.; Mrs. Charles H. Naylor; Prof. E. F. Nichols; Dr. W. H. Nichols; Mr. C. Nielsen; Mr. S. I. Oestoneider, Newark, N. J.; Mr. Thos. F. O'Keeffe; Mr. J. W. Oman, Wilkesbarre, Pa.; Mr. J. R. O'Reilly; Mr. Brett Page. Bound Brook, N. J.; Mr. W. D. Pardoe, Princeton, N. J.; Prof. H. C. Parker; Dr. H. E. Patten, Washington, D. C.; Prof. C. E. Pellew; Mr. Herbert Philipp, Perth Amboy, N. J.; Mr. O. W. Pickering, Springfield, Mass.; Mr. J. Richmond Pitman, Orange, N. J.; Gen. John Pitman, Orange, N. J.; Mr. Y. Pitman, Orange, N. J.; Dr. Henry Noel Potter; Mr. E. W. Preston, Maywood, N. J.; Mr. A. S. Ramage, Detroit, Mich.; Mr. Charles L. Rand, Brooklyn, N. Y.; Mr. A. G. Reeve, Niagara Falls, N. Y.; Mr. John Rhodin, London, England; Prof. and Mrs. Joseph W. Richards, South Bethlehem, Pa.; Mr. F. Rigg, Palmerton, Pa.; Count and Countess Andre de Riva-Berni, Paris, France; Mr. H. Rodman, Pittsburg, Pa.; Dr. E. F. Roeber; Mr. A. J. Rossi; Mr. S. S. Sadtler, Philadelphia, Pa.; Mr. Pedro G. Salom, Philadelphia, Pa.; Mr. S. E. Sanders, Niagara Falls, N. Y.; Mr. M. F. Schack, Brooklyn, N. Y.; Dr. George P. Scholl; Mrs. Thomas Schoney; Dr. S. Schoney; Mr. F. F. Schuetz; Dr. and Mrs. F. A. Seeker, Hoboken, N. J.; Dr. Felig Seeler, Rahway, N. J.; Mr. George R. Seward; Dr. C. H. Sharp; Mr. Arthur Simmers, Perth Amboy, N. J.; Mr. and Mrs. Acheson Smith, Niagara Falls, N. Y.; Mr. E. W. Smith, Philadelphia, Pa.; Mr. and Mrs. W. H. Smith, Pittsburg, Pa.; Mr. F. G. Smull, Franklin Furnace, N. J.; Mr. E. A. Sperry; Mr. E. G. Sperry, Brooklyn, N. Y.; Mr. L. Sperry, Brooklyn, N. Y.; Prof. and Mrs. C. L. Speyers, New Brunswick, N. J.; Mr. J. Lorenz Sporer; Mr. Noel Statham, Mechanicville, N. Y.; Mr. H. I. Stevens; Miss L. S. Stevenson, Poughkeepsie, N. Y.; Mr. F. P. Stockbridge; Mr. G. C. Stone; Mr. Ernest Stütz; Mr. W. H. Swenarton; Prof. W. T. Taggart, Philadelphia, Pa.; Mr. and Mrs. E. R. Taylor, Pen Yan, N. Y.; Mr. Charles E. Taylor, Pen Yan, N. Y.; Mr. B. F. Thoman, Chattanooga, Tenn.; Dr. M. Toch; Mr. F. J. Tone, Niagara Falls, N. Y.; Mr. Philip Torchio; Prof. C. C. Trowbridge; Prof. Samuel A. Tucker; Mr. L. Vorce, Detroit, Mich.; Mr. J. C. Walker; Mr. D. W. Ward, Flushing, L. I.; Mr. John W. Ward; Mr. T. D. Waring, Perth Amboy, N. J.; Mr. W. D. Weaver; Mr. Utley Wedge, Ardmore, Pa.; Mr. J. G. Wells; Dr. E. Weston, Newark, N. J.; Miss Ruth Wheeler, Brooklyn, N. Y.; Mr. W. A. Whitaker, Jr.; Dr. W. R. Whitney, Schenectady, N. Y.; Dr. and Mrs. F. G. Wiechmann, Brooklyn, N. Y.; Mr. W. G. Wiechman; Mr. C. M. Williamson, Niagara Falls, N. Y.; Mr. and Mrs. Ernst Wolff; Mr. C. I. Zimmerman, Niagara Falls, N. Y.; Dr. F. Zimmerman, Newark, N. J.; Mr. Norman E. Zusi.

* * * *

At a meeting of the New York Section of the American Electrochemical Society last year, resolutions of sympathy on the occasion of the death of Prof. Henri Moissan were adopted, after an appropriate sketch of Moissan's life and work had been given by Dr. C. A. Doremus.

These resolutions of sympathy were forwarded by Mr. A. von Isakovics, as Secretary of the New York Section, to the Department of State in Washington, and were transmitted through the American Ambassador in Paris to the widow and son of Prof. Moissan.

In the following we give a translation of Mme. Moissan's letter in reply:

"To His Excellency, the Ambassador of the United States:

"In our great sorrow, allow me to say how much my son and myself are touched by the expression of sympathy that you have wished to transmit to us in the name of the American Electrochemical Society.

"While reading the message that your Excellency has conveyed to me, it brings to mind the pleasant and enjoyable hours that our dear departed one has spent in your fine country in 1896 and 1904.

"The welcome that he received then from his colleagues across the water greatly moved him—he used to speak of it often, and with pleasure express his admiration for the industry and the progressive spirit of the Americans.

"I beg therefore that your Excellency will convey our sincerest thanks to the American Electrochemical Society, and that it will accept our heartfelt appreciation.

(Signed) "L. Henri Moissan."

The Lash Steel Process and the Electric Furnace.

From the FitzGerald & Bennie Laboratories.

In the numerous experiments that have been made with the object of producing steel direct from iron ore, one of the most serious problems was that of heating the furnace charge to the necessary temperature. In the blast furnace this is readily accomplished by mixing with the ore an excess of carbon, so that a part acts as reducing agent and a part as fuel, which gives the necessary heat by combustion in the blast. It is possible to make a mixture of ore and carbon where the latter is only present in the proportions necessary for reduction, to place this mixture in a suitable container and then to heat the latter by means of the combustion of fuel, so as to obtain an iron having the desired percentage of carbon; but such a process is not commercially feasible. In order to produce iron from the ore in a commercial manner it appears to be necessary to generate the heat in the charge itself.

The production of electric energy at a relatively low price and the consequent developments in the design of electric furnace led to the hope that the problem of the direct production of steel might be solved. Theoretically, it should be possible to place in an electric furnace a mixture of ore with only that amount of carbon necessary for reducing and for the proper carbon content in the metal to turn out the desired grade of steel. Experiment, however, has shown that this is not commercially feasible, because of technical difficulties which quickly appear when the attempt is made.

Successful experiments with the "Lash process" in the case of the open-hearth furnace on a commercial scale have indicated the possibility of its application to an electric furnace process.

In this process finely divided ore is intimately mixed with carbon, a certain quantity of finely divided carboniferous iron, such as cast iron borings or granulated pig iron, sawdust and fluxes suitable for the ore under treatment. The mixture is then ready for charging, either loose or in briquetted form, and in general it may be said that it must simply be heated to a sufficiently high temperature in order to obtain the steel.

The working of the process can perhaps be best explained by comparison with the open-hearth "ore process," which consists in first forming a bath of molten pig iron and then adding thereto a sufficient amount of ore (iron oxide) to reduce the carbon content of the metal to the desired amount. The oxygen of the ore combines with a certain amount of the carbon in the pig iron, forming carbon monoxide gas, and the iron of the ore is set free to mix with the bath of molten metal. Following this method we may work up together a mixture of approximately 75 per cent pig iron and 25 per cent ore. But in the Lash process these proportions are very different, for instead of treating a large excess of pig iron with a relatively small amount of ore, we can use a large proportion of ore with a smaller proportion of carboniferous iron.

Turning now to a more detailed examination of the Lash process, a typical mixture has the following percentage composition:

Iron ore	54
Cast iron borings or granulated pig iron	27
Sawdust	4
Limestone	4
Coal tar	3
Coke	8
	100

All the constituents of this composition are in a fine state of division intimately mixed, and when heated to a sufficiently high temperature the chemical reaction between the carbonaceous material and the ore proceeds readily, the iron oxide being reduced by the carbon, forming carbon monoxide gas and metallic iron. The function of the sawdust in the mixture is to make it porous, since at an early stage of the heating the sawdust carbonizes and leaves the mass in a porous state, permitting the easy escape of the gases formed during the reaction.

If we imagine the Lash mixture given above, heated to a high temperature, it is easy to see that the reactions which occur are similar to those found in the open-hearth furnace using the ore process. The cast iron borings correspond to the molten bath of pig iron and react with the ore, but the latter being in large excess it is necessary to supply a certain amount of free carbon in the form of coke, to supply sufficient carbon for the complete reduction of ore.

It is perfectly obvious where the great economy of the Lash process is found, since the proportion of ore to pig iron is very much greater than in the ordinary open-hearth process, where a large amount of pig iron and a relatively small amount of ore, or a mixture of pig iron and scrap, must be used. Put briefly, the Lash process is a method whereby a large amount of relatively cheap iron in the form of ore may be used to replace more expensive pig iron or scrap.

Now, in using the Lash mixture in the open-hearth furnace it is necessary to have a bath of molten metal, for were it to be charged into an empty open-hearth furnace it would not be practicable to heat it to the reacting temperature without losing carbon in the mixture by combustion. If, however, the charge is put into an electric furnace no difficulty of this kind is met with, since the gas in an electric furnace is neutral in contradistinction to the oxidizing atmosphere of an open-hearth furnace.

Experiments using the Lash mixture have been made in the electric furnace on a small scale, and the results have been very successful. In these experiments no bath of pig iron was used, but the mixture was heated alone in an electric furnace. It was found that the yield of metal amounted to 98 per cent of the metallic content of the mixture. Using electric energy as a source of heat is in general more expensive than heating by fuel, in spite of the fact that the heat generated is used much more efficiently in the electric than in fuel furnaces; but the economy in the electric furnace is found in the saving of pig iron, which must be used in the open-hearth process.

Thus, the average cost of the Lash process in the open-hearth furnace for Canada to produce 100 tons of ingots is as follows:

124 tons mixture	at	$6 00	$755 16	60% metallic	74 4	tons.
32 " pig	at	22 00	704 00	95% "	30 4	"
2 " ore	at	5 00	10 00	60% "	1 20	"
½ " ferro.	at	62 00	31 00	Total contents	106 00	"
Total cost charge			$1,500 16			
Credit 2 tons scrap	at	$18 00	36 00			
			$1,464 16			
Cost per ton					$14 64	
Cost conversion					4 00	
					$18 64	

If, on the other hand, the electric furnace is used, we would have the following figures:

174 7 tons mixture	at	$6 00	$1,063 92	60% metallic	104 8	tons.
2 " ore	at	5 00	10 00	60% "	1 2	"
0 5 " ferro.	at	62 00	31 00	Total contents	106 0	"
Total cost charge			$1,104 92			
Credit 2 tons scrap	at	$18 00	36 00			
			$1,068 92			
Cost per ton					$11 69	
Allowable cost of conversion in electric furnace to make total cost same as O H furnace					7 95	
					$18 64	

Now, the experimental work carried out in the electric furnace for the reduction of iron ore indicates that the cost of conversion should be as low or less than $7.95 per ton and arrangements have therefore been made to test various electric furnaces, with the object of finding out those forms to which the Lash process is applicable.

Recapitulating, the electric furnace cannot be used at the

present time for the direct production of steel, owing to certain technical difficulties, but by applying the Lash process for the production of steel in the open-hearth furnace, with suitable modifications for the electric furnace, it is believed that the problem can be solved. Therefore, in all cases where for whatever reason the use of the electric rather than fuel furnace is desirable, steel may be produced directly from the ore in the former.

Oxygen in the Arts.

By Cecil Lightfoot.

Of the various factors which have hitherto militated against the more general application of oxygen in the arts and industries, the principal has, without doubt, been the impossibility of obtaining it in sufficiently large quantities at a sufficiently low cost. The rapid development which is taking place in the application of Dr. Carl von Linde's method of producing oxygen from the atmosphere by fractionation, offers good reason for the belief that a much more general use will be made of oxygen, particularly in metallurgical operations in the near future.

It is probable, however, that in most cases oxygen will not be employed in a state of purity, but will be used for the purpose of adding from 5 to 10 per cent to the quantity present in the normal air supply. In the case of a blast furnace the enrichment of the blast by the addition of 5 per cent of oxygen would have marked effects, which, so far as one can see should be distinctly beneficial. The first result would be to reduce the capacity of the blowing engines by 20 per cent. The absence of such a large volume of nitrogen would not only in all probability effect a considerable economy in the fuel consumption, but the furnace gases would have a much higher thermal value. It is conceivable that a plant to produce oxygen may, in the near future, become a necessary adjunct to the blast furnace. On such a scale the cost of the oxygen would be reduced to a very small amount.

In the same way it is highly probable that considerable economy would be introduced into other smelting operations by the use of oxygen, as, for instance, in the reduction of copper, and in the production of zinc, nickel and other metals. For the production of Bessemer steel the addition of a comparatively small quantity of oxygen during the first part of the blow would at once provide a means for reducing the time necessary for the operation. It would, in fact, seem that the process lends itself particularly to this application in view of the small amount of silicon in so much of the ore in this country.

German Bunsen Society.

The fourteenth annual meeting of the German Bunsen Society for Applied Chemistry was held in Hamburg, and a complete report of the proceedings is given in *Zeit. f. Elektrochemie*, June 28, July 5, 19, Aug. 9 and 16. The president, Prof. Walter Nernst, was in the chair. Geheimrat Dr. von Boettinger has granted a fund for a gold Bunsen medal to be granted every two years. The number of members is 702, among which are ten honorary members and twelve life members. The next annual meeting will be held in Vienna.

Radioactivity and Disintegration of Atoms.—A symposium of papers on this subject was the program of the first session. All these papers may be found in *Zeit. f. Elektrochemie*, July 5. Prof. Voller gave an introductory sketch of radioactivity. He concisely reviewed the investigations on electric discharges through rarified gases, and especially on the phenomena of cathode rays, which have led to the conceptions of negative corpuscles or electrons in the cathode rays and of positive ions in the anode radiation; on the other hand, Roentgen rays carry no measurable charges. Then came the detection of radioactive substances and the discovery of three kinds of radiations from them: alpha rays with positive charges, beta rays with negative charges, and gamma rays without charges. For discharges through rarified gases the conclusion was reached that we have to do with a disintegration of atoms which give off electrons. On account of the analogy sketched above the question arises whether we also have to do with disintegration of atoms in the phenomena of radioactivity. The tendency is now to give an affirmative answer to this question.

Prof. W. Marckwald spoke of the chemical behavior of radioactive substances. We have to assume now some twenty new radioactive elements. Most of them are known only from their radiating ability and characterized by their constants of decay. The author sketched the methods of winning radium from pitch-blende, the electrolytic separation of polonium from bismuth in pitch-blende, the chemical properties of actinium and of the so-called emanations (apparently inert gases of the argon type). The separation of the radioactive disintegration products of the emanation is partly possible by electrolysis, for instance, the separation of thorium A from thorium B.

Prof. G. Meyer spoke on the production of helium from radioactive substances. Ramsay and Soddy found in 1903 by spectroscopic methods that helium is formed from radium. Other investigators confirmed this experimental result. The objection has been raised that the helium observed in the spectral tubes was gas occluded in the radioactive substances and taken over in their preparation from the uranium ore. More recent experiments by F. Himsted and G. Meyer show that this explanation is not valid. It is a fact that salts of radium and actinium produce helium, that this is not gas taken over from the uranium ore, and that its fixation in the radioactive substances is different from occlusion or chemical combination of gases. According to Rutherford's hypothesis, helium is formed from the alpha particles. All disintegration products of radium, which give off alpha rays, should therefore produce helium.

Dr. F. Von Lerch spoke on the nature of radiactive radiation. The alpha, beta and gamma rays behave differently with respect to deflection by magnetic and electric force (from which the speed and the ratio of charge to mass may be determined), with respect to penetration through different materials, and with respect to the ionization which they produce. As to the deflection by magnetic and electric forces, alpha rays are slightly deflected in a direction indicating that they carry a positive charge. Beta rays are strongly deflected in a direction indicating that they are negatively charged. Gamma rays are not deflected. As to absorption, alpha rays are absorbed by mica or aluminium plates 0.1 mm. thick; beta rays are absorbed by aluminium 5 mm. thick, or by lead 2 mm. thick; gamma rays pass even through 300 mm. thick iron. The ionizations produced by alpha, beta and gamma rays, respectively, are roughly in the relation of 10,000 to 100 to 1.

The gamma rays from radium are not homogeneous; only the rest which is left after the rays have passed through thick lead plates has a constant coefficient of absorption. The gamma rays only occur together with beta rays. Gamma rays are apparently produced at places where beta rays are absorbed.

The beta rays have a velocity between one-fifth and nine-tenths of the velocity of light. The ratio of charge to mass for a corpuscle is not constant, but decreases with the speed. For the lowest speeds the ratio gets approximately that of cathode rays, so that the radiated particles or corpuscles may be assumed to be the same in both cases. The mass of such a particle is about one-two thousandth of the mass of a hydrogen atom. The beta rays of radium and thorium are not homogeneous.

For the alpha particles the ratio of charge to mass is 0.507×10^4, and this value is the same for the alpha particles radiated from any substance. The alpha particles resulting from the different evolution products of radium and from radium itself

are identical with those from actinium and those from thorium. The ratio of charge to mass for the electrolytic hydrogen ion is 10^4, hence twice the ratio of the charge to mass of the alpha particle. Since the assumption is now made that the helium produced from radioactive substances consists of alpha particles, and since the atomic weight of helium is 4, two hypotheses are possible. Either the alpha particle is one-half helium atom with the charge of the hydrogen ion, or the alpha particle consists of a whole helium atom charged with two elementary electric charges.

Alpha particles emitted from different substances differ only with respect to their speed (not with respect to the ratio of charge to mass). For a homogeneous radioactive substance the speed with which all particles are emitted is the same, and the initial speed is a characteristic constant of the substance. The alpha particles ionize the air only within a certain distance; this is a constant which may be easily determined. At the same distance the alpha particles lose their photographic activity and their effect on a phosphorescent screen.

Dr. Otto Hahn discussed Rutherford and Soddy's hypothesis of the disintegration of atoms. He sketched the experimental work on which it is based, and gave a graphical table showing the evolution due to atomic disintegration, of uranium, sodium, actinium and thorium. For radium, for instance, we have: Ra, giving off alpha rays, forms (2,600 years) Em, which giving alpha rays, forms (3.8 days) RaA, which giving off alpha rays, forms (3 minutes) RaB, which giving off beta rays, forms (26 minutes) RaC, which giving off alpha rays and beta and gamma rays, forms (19 minutes) RaD, which forms (about forty years?) RaE_1, which forms (6 days) RaE_2, which giving off beta rays forms (4.8 days) RaF, which is nothing else but the polonium of Mrs. Curie and the radiotellurium of Marckwald. This disintegrates (143 days) forming probably ordinary lead.

The figures given above in parentheses represent the time in which the activity decreases to one-half its original value. For instance, the activity of any sample of radium decreases to one-half in 2,600 years. From 1 gram of radium there would be left as radium proper only ½ gram. The other half would partly have escaped as helium, but the greater part would be in form of an inactive final disintegration product mixed with radium.

In the discussion, Prof. Landolt referred to the very extended researches which he has made to test by weighing the constancy of mass in chemical reactions. While he had found in all cases a very slight diminution of weight, he has now traced this to a source of error, namely, the slowness with which the glass vessels return to their original volume from the increased volume due to heat. "The question whether the law of the conservation of mass when tested experimentally has perhaps been found to be not absolutely correct, has now been answered in the negative."

Dr. M. Levin discussed some consequences of the hypothesis of atomic disintegration, especially the age of minerals and the part which radium plays in the heat economy of the earth and the sun. Prof. F. Henrich discussed the radioactivity of air and spring waters.

Finally, a general discussion was held. Prof Tammann brought up the question whether the "radioactive elements" are really elements. Prof. Nernst thought this to be simply a matter of definition, but Tammann did not think so; the latter also raised the question, where to place the radioactive elements in the periodic system. Dr. Hahn replied that Rutherford always emphasizes that the quickly disintegrating radioactive products should not be expected to fill gaps in the periodic system. The periodic system appears to represent elements with a certain stability. Prof Brauer brought up the other question, why there exist gaps in the periodic system, especially in the highest regions. "Why have we no more element after bismuth (208) until radium? Then there is another gap till thorium, then comes uranium, and that is all I believe that may be explained by the following hypothesis, though I can't prove it. I assume that there are dead extinct elements which exist no longer, but have been disintegrated. Why not? Why should there be no elements of short life?" Prof. Nernst seemed to feel somewhat dejected by this idea and offered the more joyful hypothesis that some elements have not yet been borne.

Atomic Weights.—One of two papers dealing with this subject was presented by Prof. B. Brauner (*Zeit. f. Elektrochemie*, July 19). He spoke in the most complimentary terms of the classical researches of Theodore W. Richards, of Harvard, and then criticized the table of atomic weights of the International Committee. The new values of Richards should be adopted, and the committee should not avoid the trouble of revising the whole table if this becomes necessary as the result of modern researches.

Dr. A. L. Bernoulli presented a paper (*Zeit. f. Elektrochemie*, Aug. 16) in which he gave on the basis of thermodynamics a recursion formula of atomic weights. It is essentially a development of Lockyer's idea that the series of the atomic weights of the stable conditions of hydrogen represents the series of atomic weights of all imaginable chemical elements. The series calculated by the author agrees remarkably well with actual values.

Compressibility of Elements.—Prof. Th. W. Richards (Harvard) described a differential apparatus devised by him for determining the compressibility of substances, and gave the results of the determination of the compressibilities of thirty-five elements. The values vary greatly for different substances. Thus silicon, which is probably the least compressible element, has a compressibility of 0.00000016, while the value for chlorine is, for instance, 0.00009. The values of the compressibility are a periodic function of the atomic weights. The paper may be found in *Zeit. f. Elektrochemie*, Aug. 9 while the full account of the investigation has been issued as No. 76 of the publications of the Carnegie Institute, of Washington.

Fused Salts.—A paper by Dr. K. Arndt (*Zeit. f. Elektrochemie*, Aug. 9) gave the results of some measurements of the conductivity of fused salts. Of special interests are the tests of a fused mixture of a salt of good conductivity and a non-conductor, namely, a solution of fused $NaPO_3$ (conductor) in fused B_2O_3 (practically a non-conductor) at 900° C. The equivalent conductivity decreases much more rapidly than the concentration; simultaneously, the tenacity increases with decreasing concentration. The product of equivalent conductivity and tenacity is constant. "The decrease of equivalent conductivity may therefore be thought to be due to the increase of internal friction of the solution; it follows that the degree of dissociation of the dissolved fused salt does not vary with dilution. This phenomenon may be explained in the simplest way by the assumption that the fused sodium metaphosphate is completely ionized." A second paper of the author on the measurement of tenacity at high temperatures may be found in *Zeit. f. Elektrochemie*, Aug. 23.

Synthesis of Ammonia.—A paper by Prof W. Nernst (*Zeit. f. Elektrochemie*, Aug. 9) dealt with the equilibrium of the reversible reaction $2NH_3 \rightleftharpoons 3H_2 + N_2$. A thermodynamical theory of Nernst on chemical equilibria had been found, in this single case, to be in poor agreement with the results of measurements. For a partial pressure 0.0002 of ammonia, formed at atmospheric pressure, Nernst's theory had given the absolute temperature 893, while Haber and van Oordt had found experimentally 1,293. From recent measurements of Nernst and Jost it appears that the former poor disagreement was due to sources of error in the former experimental method. At the high temperatures at which Haber had to work on account of the low speed of formation of ammonia from nitrogen and hydrogen, he got only a very small yield. According to the law of mass action this yield may be increased by increasing

the pressure. For this reason Nernst and Jost employed a small electric furnace, in which the reaction between the gases was brought about at a high pressure and at strictly defined temperatures. The agreement between experiment and theory is now much better. The new figures show, however, that the synthesis of ammonia from nitrogen and hydrogen is by no means as promising a problem as had formerly been thought.

Effect of Light on the Formation of Sulphuric Acid.—A paper by Prof. Coehn described experiments showing that light from a quartz arc lamp strongly accelerates the reaction $3SO_2 = 2SO_3 + S$, and also the reaction $2SO_2 + O_2 = 2SO_3$. For both reactions it is essential that the reaction gases have not been dried beyond a certain degree of humidity. If we have to do here with a displacement of the equilibrium, due to light, it must be possible to reach the equilibrium also from the other side. Indeed, it was found that SO_3, under the influence of light, was dissociated into O_2 and SO_2, and that the equilibrium which was reached in this way was about the same as when it was reached from the other side. In both cases it seems that the ultra-violet rays are those which are specially active.

The action of the light is, however, not the same in the formation and in the dissociation of SO_3. In the formation of SO_3, that is, in the reaction of $2SO_2 + O_2 = 2SO_3$, the light acts like a catalytic agent, while in the dissociation of SO_3, that is, in the reaction $2SO_3 = 2SO_2 + O_2$ the light performs work. From this it follows that the stronger the light the greater is the dissociation of SO_3 in the condition of equilibrium. Hence, if we want to form SO_3 from SO_2 and O_2, the gas mixture in state of equilibrium will contain a smaller percentage of SO_3 the stronger the light effect. This apparent paradox was confirmed experimentally by operating the quartz arc lamp at 6 and 9 amps.

A paper by Dr. Trautz (*Zeit. f. Elektrochemie*, Aug. 16) dealt with some special cases of the influence of variation of temperature on the speed of reaction in photochemical reactions.

Influence of Temperature on Metal Deposition.—Prof. F. Foerster's paper on this subject (*Zeit. f. Elektrochemie*, Aug. 16) first referred to the well-known effect of improving the solidity of metallic deposits (for instance, nickel) by an increase in temperature. This is due to increased diffusion and stronger circulation, as a result of which fresh metal ions are continually brought right to the cathode surface on which they are to be deposited. However, the present paper shows that an increase of temperature may also have in special cases an essentially different effect, namely, a decrease of the "reaction resistances" which render metallic deposition difficult. For instance, for the deposition of copper from a cyanide solution the required voltage increases considerably, with increasing current density, at 18° C., while the corresponding increase of the required voltage is very much less at higher temperatures. An increase in temperature may change in such cases the position of the metal in the "nobility" series, for instance, compared with hydrogen. Prof. Foerster showed that this principle permits interesting applications to the separation of different metals.

Miscellaneous Papers.—The balance of the papers presented at the meeting dealt with the following subjects: Prof. R. Luther, on electrochemical "activity phenomena" (with reference to vanadic acid in electrolysis); Prof. R. Abegg, on two new potentials $NO_2' \rightarrow NO_2$ (1.2 volts), and $Au' \rightarrow Au$ (1.46 volts); Dr. W. Guertler, on the electric resistance of metallic alloys, with special reference to the occurrence of alloy crystals; Prof. Karl Scheel, on the determination of the coefficients of refraction of gases at ordinary temperature and at the temperature of liquid air; Prof. Emil Bose, on the physical properties of emulsions, especially on their relation to the crystalline liquids; Prof. F. Haber, on the gas refractometer, *i. e.*, on determination of density by measurement of the coefficient of refraction (all these papers being published in *Zeit. f. Elektrochemie*, July 19); further, Prof. Walther Loeb, on the chemical theory of alcoholic fermentation; Dr. Jordis, on further researches on silicates, a contribution to the chemistry of colloids; Dr. H. Bechhold, on studies of colloids by the filtration method; Dr. R. O. Herzog, on diffusion of colloids (all these papers being published in *Zeit. f. Elektrochemie*, Aug. 9); further, Dr. E. Abel, on intermediary reactions in catalysis, and Dr. Max Von Vogau, on diffusion of metals in mercury (*Zeit. f. Elektrochemie*, Aug. 16).

Metallurgical Calculations.

By Jos. W. Richards, Ph. D.,
Professor of Metallurgy in Lehigh University.

(*Continued from page* 405.)

I. 4. Electrolytic Refining of Impure Copper.

This subject is a large one. It lends itself very well to calculation. It is also comparatively simple in principle. Given a nearly pure copper plate or slab as an anode, in a solution of a copper salt, and a suitable conducting cathode, the metal is simply dissolved and deposited, or is "plated over." The process really consists in extracting copper from the solution at the cathode, and sending it and other soluble impurities into the solution at the anode. The mechanical transportation of the copper, in space, through a distance equal to the space between anode and cathode, is sometimes emphasized as the chief mechanical work done. It is a real fact that the metal is taken out of the solution at a different spot from where it goes in, but the electric current does not do that transportation—diffusion and circulation are the agents which transport the copper entering the electrolyte at the surface of the anode plate to the surface of the cathode plate, and electric energy does nothing more than create the differences of concentration, which are thus physically neutralized.

The chief expenditure of electrical energy in the refining bath is that converted into sensible heat in overcoming the ohmic resistance of the electrolyte. The other items of electrical work are the overcoming of the ohmic resistance of hangers, rods, bus-bars, clamps and connectors, and the not unimportant resistance of contacts; also the difference of chemical work done in depositing all copper and dissolving part copper and part other impurities; also the chemical work of separating the ingredients of the impure copper, which may be alloyed and have some heat of combination which must be furnished by the current in order to separate them.

Energy Absorbed by the Electrolyte.

The electrolyte is a conductor and absorbs energy according to Ohm's law whenever current passes through it. The solution used in copper refining is almost invariably copper sulphate acidulated with sulphuric acid. The resistivity of copper sulphate, iron sulphate and sulphuric acid solutions, at 20° C., is as follows, in ohms per centimeter cube and ohms per inch cube:

Per Cent.	*$CuSO^4$.*		*$FeSO^4$.*		*H^2SO^4.*	
in Solution.	*Ω per $cm.^3$*	*Ω per $inch^3$.*	*Ω per $cm.^3$*	*Ω per $inch^3$.*	*Ω per $cm.^3$*	*Ω per $inch^3$.*
2.5	92	37	..	..	....	....
5.	53	21	..	..	4.8	1.9
7.5	..	..	65	26	....	....
10.	31	12	..	..	2.5	1.0
15.	24	10	34	14	1.8	0.7
17.5	22	9	..	..	....	....
20.	..	..	..	..	1.5	0.6
25.	..	..	..	..	1.4	0.56
30.	..	..	25	10	1.37	0.55

The plain copper sulphate solution is thus seen to be a rather

poor conductor; iron sulphate is not so good; sulphuric acid is highly conducting. It is therefore evident that the ohmic resistance of the bath is, for practical purposes, dependent upon its content in free acid; hence the great economic importance of keeping the bath well acidulated. As the bath grows foul with iron sulphate and loses sulphuric acid by formation of insoluble sulphates, chemical solution of slimes, etc., the bath becomes poorer conducting and the energy absorbed in it much greater. A solution in good condition, with 15 to 20 per cent of $CuSO^4$ and 5 to 10 per cent free H^2SO^4, may have a resistivity of only 2 to 5 ohms at starting, which may increase to 20 or 25 ohms as the solution becomes impure and the free acid disappears. These facts are of immense importance in the economics of refining.

A comprehensive, systematic study of the resistivities of solutions of various strengths of copper sulphate with various percentages of iron sulphate present and various content of sulphuric acid is greatly needed, and would not be a difficult research to carry out. One of the writer's electrometallurgical students is at present engaged on this work.

Problem 118.

A refining bath is run with a current density of 250 amperes per square meter, with electrodes 4 c.m. apart, and starting with electrolyte 15 per cent $CuSO^4$ and 10 per cent H^2SO^4. It is run until the sulphuric acid has decreased to 5 per cent.

Required:

(1) The probable voltage drop across the electrodes at starting.

(2) The same when the second condition is reached.

(3) The rate at which the solution would start to rise in temperature at the beginning, ignoring the electrodes.

(4) The rate, assuming anodes 5 c.m. thick and copper cathodes 0.5 c. m. thick.

Solution:

(1) Lacking the experimentally determined datum of the resistivity of the primary solution, we know that it will be somewhere about that of the 10 per cent sulphuric acid solution, viz.: 2.5 ohms. It should be slightly less, because of the copper salt present, and if we assume the conductivity of the solutions as additive, we would have a conductivity of the mixed solution, in reciprocal ohms as

$$C = \frac{1}{2.5} + \frac{1}{24} = 0.40 + 0.04 = 0.44$$

$$R_{sp.} = \frac{1}{0.44} = 2.3 \text{ ohms.}$$

Using this resistivity, the voltage drop across the electrodes, at starting, will be

$$V^e = 2.3 \times 4 \times 0.0250 = 0.23 \text{ volts.} \qquad (1)$$

(0.0250 amperes goes across each square centimeter and the plates are 4 centimeters apart.)

(2) With H^2SO^4 only 5 per cent, and copper contents, say, 20 per cent, because of solution of copper by free acid, we would have

$$C = \frac{1}{4.8} + \frac{1}{20} = 0.1 + 0.05 = 0.26$$

$$R_{sp.} = \frac{1}{0.26} = 3.6 \text{ ohms.}$$

Using this resistivity, the voltage drop is

$$V^e = 3.6 \times 4 \times 0.0250 = 0.36 \text{ volts.} \qquad (2)$$

In actual practice an increase of 0.01 volt above this might be expected, because of the formation of a film of slime on the surface of the anode.

(3) The solution at starting has a specific gravity of 1.20 and a specific heat of 0.875. (Combination of data from Landolt-Bornstein-Meyerhoffer's Tabellen.) The water value as heat absorber of a column of liquid 1 c m.^{2} and 4 c m. long, between the electrodes, is therefore

$$1.2 \times 4 \times 0.875 = 4.2 \text{ calories per } 1^\circ \text{ C.}$$

Heat equivalent of the electric energy expended

$$0.23 \times 0.0250 \times 0.2389 = 0.00138 \text{ calories per } 1''.$$

Rate of rise of temperature of solution

$$0.00138 \div 4.2 = 0.00032^\circ \text{ per second}$$
$$= 0.0198^\circ \text{ " minute}$$
$$= 1.2^\circ \text{ " hour} \qquad (3)$$
$$= 28.8^\circ \text{ " day}$$

(4) With half the thickness of anode and cathode to be supplied with heat, the copper having a specific gravity of 8.9 and specific heat of 0.093, the water value of the copper concerned per square centimeter area of electrolyte section is

$$\left(\frac{5.0}{2} + \frac{0.5}{2}\right) \times 8.9 \times 0.093 = 2.276 \text{ calories per } 1^\circ.$$

Rate of rise of temperature of solution plus electrodes:

$$0.00138 \div (2.276 + 4.2) = 0.00021^\circ \text{ per second}$$
$$= 0.013^\circ \text{ " minute}$$
$$= 0.78^\circ \text{ " hour}$$
$$= 18.7^\circ \text{ " day} \qquad (4)$$

Energy Lost in Contacts.

This is an extremely variable and yet important factor in the economics of copper refining. No one item in copper refining will at the present time better repay close attention and study of methods of improvement. A proper contact should cause a very small voltage drop to begin with, and should be capable of being kept efficient—that is the chief requirement. Contacts are often made on the hit or miss style, and arranged in such position as to receive spattering or drippings from the electrolyte; such may cause immense losses of electrical energy as they rapidly pass from bad to worse.

B. Magnus (ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, December, 1903), and L. Addicks (*idem.*, January, 1904) have given us valuable information on this point. The weight of the plates, when resting on the contacts, improves the contact; in such cases the anode contacts are best when the tank is first set up and the cathode contacts worst. In such cases a screw clamp, to put several hundred pounds of mechanically applied pressure on the joint, should be adopted, so as to make the contacts "best" all the time

Figures given by Magnus as a carefully determined average of results in a Western refinery are:

				Per Cent.
Current	4,000 amperes			
Current density (per sq. ft.)	11 "			
Total voltage per tank	0.230 volts			
Energy used per tank	0.920 kw.			
Drop, bus bar to anode rod	0.0270 volts			
" anode rod to anode hanger	0.0060 "		= 0.0338 =	14.7
" anode hook to anode	0.0008 "			
" anode to cathode	0.1782 "		= 0.1782 =	77.5
" cathode to cathode rod	0.0045 "			
" cathode rod to bus bar	0.0135 "		= 0.0180 =	7.8
			0.2300	100.0

It thus appears that in this tank the loss in contacts was some 20 per cent of the total voltage employed (assuming the anode rods to be of such design that their resistance was negligible). Magnus fitted up a similar tank with mercury cup contacts, and found a drop from bus-bar to anode rod of 0.0050 volt instead of 0.0270, and cathode rod to bus-bar 0.0050 instead of 0.0135 volt. If it were possible in the case of above tank to make these improvements alone, the saving on voltage per tank would be 0.0305 volt, or 13.3 per cent of the voltage used, which means a saving of 13.3 per cent of the power required to run the tank.

Problem 119.

In an electrolytic refinery system of 200 tanks the resistance of the contacts was, on an average, 0.0368 volt per tank, and 0.2567 volt across two electrodes; 3,800 amperes was passed through the series, and the voltage at the terminals of the dynamo was 67 volts. Power costs $157 per kilowatt-year. Efficiency of deposition of copper 82 per cent.

Required:

(1) The cost of power per ton (2,000 pounds) of copper refined.

(2) The cost per ton of copper produced of the power lost by (a) resistance of the conductor bars (b) by the contacts, and (c) consumed in the electrolyte itself.

(3) If interest on capital is 6 per cent, what expenditure would be justified on means for (a) reducing the conductor losses (b), reducing the contact losses (c), reducing the electrolyte losses?

(4) If the ampere efficiency of deposition could be increased 5 per cent by reducing the current density 20 per cent, would it pay?

Solution:

(1) Copper deposited in 1 tank per day

$$3800 \times 0.82 = 3118 \text{ oz.} = 195 \text{ lbs.}$$

In 200 tanks

$$200 \times 195 = 39{,}000 \text{ "}$$

Power used

$$3800 \times 67 \div 1000 = 255 \text{ kw.}$$

Cost of power per day

$$255 \times \$157 \div 365 = \$109.70$$

Cost of power per 2,000 lbs. copper

$$\$109.70 \div 19.5 = \$5.63 \qquad (1)$$

(2) The voltage lost in the conductors is

$$67 - 200(0.0368 + 0.2567) = 67 - 58.7 = 8.3 \text{ volts}$$

and the power thus lost

$$3800 \times 8.3 \div 1000 = 31.54 \text{ kw.}$$

Cost per year $31.54 \times 157 = \$4{,}952.00$

Cost per day $4952 \div 365 = \$13.57$

Cost per ton of copper produced = $0.70 (2a)

Power lost in the contacts

$$200 \times 0.0368 \times 3800 \div 1000 = 27.97 \text{ kw.}$$

Cost, per year = $4,391.00

Cost, per day = $12.03

Cost, per ton = $0.62 (2b)

Power consumed in the electrolyte

$$200 \times 0.2567 \times 3800 \div 1000 = 195 \text{ kw.}$$

Cost, per year = $30,615.00

Cost, per day = $83.88

Cost, per ton = $4.30 (3b)

(3) The cost of the power lost per year, divided by 0.06, will give the capital investment representing that yearly outlay. This would be

	Cost of Power.	*Capitalized.*
Conductor resistances	$4,952	$82,530
Contact resistances	4,391	73,180
Electrolyte resistances	30,615	510,250

In the specific cases in point each 1 per cent of the power consumption which could be saved by improvements of a permanent character, not subject to depreciation, would justify capital expenditures in the plant up to the following amounts:

Conductor resistances	$825
Contact resistances	732
Electrolyte resistances	5,100

If the improvements were liable to depreciation in use, such as larger tanks, contact clamps, etc., the depreciation must be added to the interest to find the justifiable capital expenditure. Assuming depreciation 10 and 20 per cent, respectively, this plus interest amounts to 16 and 26 per cent, and the justified expenditures must be less than the following amounts for 1 per cent saving of power in each direction:

	10% *Depreciation.*	20% *Depreciation.*
Conductor resistances	$309.50	$190.50
Contact resistances	274.50	169.00
Electrolyte resistances	1,913.50	736.00

There is here a wide field for experiment and improvement. In the case in point, making all allowances, one would be justified in expending in permanent plant for each tank at least $1.00 for every 1 per cent reduction which could be made in the power loss in the conductors, $0.85 for every 1 per cent gained in reducing contact resistances and $3.68 for each 1 per cent reduction in the resistance of the electrolyte. To be more specific, assume the main conductors to be proportioned to carry 2,000 amperes per square inch of cross-section. Their resistance in the case in point is $8.3 \div 3{,}800 = 0.0022$ ohm, cross-section 1.9 square inches, resistance per running inch $0.00000067 \div 1.9 = 0.00000035$ ohm, and total length $0.0022 \div 0.00000035 = 6{,}286$ inches = 524 feet.

The weight, at $62.5 \times 8.9 \div 1{,}728 = 0.322$ lbs. per cubic inch is

$$6{,}286 \times 1.9 \times 0.322 = 3{,}846 \text{ lbs.}$$

which at $0.20 per lb. costs

$$\$3{,}846 \times 0.20 = \$769.20$$

Since there is practically no depreciation (except change in market value) in these copper conductors, if we increased the cross-section of the conductors 100, 200, 300, 400 per cent, respectively, we would decrease their resistance 50, 67, 75 and 80 per cent, respectively, and arrive at the following figures:

		Per Ton of Copper Produced.			
Per Cent. Increased Size of Conductors.	*Per Cent. Decreased Resistance of Conductors.*	*Interest on Increased Cost of Plant.*	*Increased Cost of Plant.*	*Decreased Cost of Power.*	*Gain.*
100	50	$769	$0.0065	$0.35	$0.35
200	67	1,538	0.013	0.47	0.46
300	75	2,307	0.019	0.52	0.50
400	80	3,077	0.026	0.56	0.53
900	90	6,923	0.058	0.63	0.57
1,900	95	14,613	0.123	0.67	0.54

We thus see that for this plant, with power costing $157 a kilowatt-year and copper bar $0.20 per pound, a great reduction in the power costs up to $0.57 per ton of copper produced can be made by making the main conductors *ten times* as large; that is, by making them carry only 200 amperes per square inch of section instead of 2,000.

At a locality like Great Falls, Montana, where the water power does not cost over one-tenth the above price, let us say $15.70 per kilowatt-year, the decreased cost of power, in the above table would be one-tenth the above figures—there would be only $0.07 per ton of copper to save if all were saved, and it can easily be seen that the gains would be

for	100	per cent.	increased	size	$0.029
"	200	"	"	"	0.034
"	300	"	"	"	0.033
"	400	"	"	"	0.030

We reach the maximum saving in this case by increasing the size 200 per cent, giving a current density of 660 amperes per square inch of conductor section.

It can easily be seen that the cost of copper bars, rate of interest, and cost of power are all three factors in determining the economic size to be given the conductors. In general they are made much smaller than they should be because of lack of capital to invest in them. As soon as a refinery is running and paying dividends part of its profits should be ap-

plied to permanent investment in heavier copper conductors in order to reduce the running costs.

(4) If the ampere efficiency were increased 5 per cent and the current density 20 per cent, all other data being constant except those affected by these changes, the output of copper would be 87 per cent of the theoretical output of 3,040 amperes instead of 82 per cent of the theoretical output of 3,800 amperes. The output of copper per day would therefore be, in place of 39,000 pounds:

$$3{,}040 \times 0.87 \times 200 \div 16 = 33{,}060 \text{ lbs. per day.}$$

The power cost will be reduced 20 per cent by the lower amperage used, that is, be \$5.63 × 0.80 = \$4.50 per ton—a saving of \$1.13. Whether it will pay to do this depends of what the other fixed charges of the plant are. Decreasing the output 15 per cent increases the fixed charges per ton of copper produced 12 per cent. It is then a question whether 12 per cent of the fixed charges in the first case is greater or less than \$1.13. If the fixed charges amounted to, say, a usual figure of \$5.00 per ton, decreasing the output 15 per cent. would increase this charge per ton of copper produced 12 per cent, or \$0.60; but if there is a power saving of \$1.13 there is a margin of \$0.53 per ton in favor of making the change. If the power cost were only \$0.56 per ton of copper it would just barely pay to make the change. Everything depends upon the relative cost of power and of the other fixed charges.

Energy Lost in Conductors.

We have already touched on this subject, but it deserves still greater attention. The resistivity of copper is 0.00000167 ohm per centimeter cube, or 0.00000067 ohm per inch cube. Given a conductor of certain length its resistance in ohms is 0.00000167 multiplied by its length in centimeters and divided by its cross sectional area in square centimeters. The similar calculation can be made for the inch units. The drop in potential in the bus-bars is their resistance multiplied by the amperes passing, and the power consumption is the voltage drop into the amperes passing or the resistance in ohms into the square of the amperes passing. The watts thus expended may be expressed in kilowatts, or transposed into horse-power by dividing by 746. The heat generated in the conductors is, per second, in gram calories, the number of watts expended in them multiplied by 0.2389. The rate of rise of temperature of the conductors, leaving out radiation and conduction to the air, will be, per second, the gram calories generated in the conductors divided by the heat capacity of the conductors per degree, which in the case of copper is volume in cubic centimeters into 0.837. This rise in temperature will continue until by radiation and conduction to the air the conductors lose as much heat per second as the current generates in them. This will vary with the shape of the cross section of the conductors, because the loss of heat is proportional to the surface exposed, and the area of exposed surface for a given cross section is greater the thinner the conductor and is a minimum for a round conductor. The amount of heat thus lost can be calculated by the principles explained in Metallurgical Calculations, Part I., pp. 172 186. If it is desired to get along with the minimum heating of the conductors, they should be as flat and thin as possible; if heating can be ignored they may be of the cheap round shape. It should not be forgotten also that the resistivity of copper increases as it gets hotter in direct proportion to its absolute temperature (C + 273), so that the heating effect really aggravates itself from this increased resistance.

Problem 120.

A copper conductor is desired to carry 4,000 amperes, 300 meters. Round bars sell at 18 cents per pound. Interest rate 10 per cent. Cost of electric power as delivered \$50 per kilowatt year. Average temperature of surrounding air 20° C. air still. Conductivity of the copper 600,000 reciprocal ohms per centimeter cube. Specific gravity of copper 8.9, specific heat 0.094.

Aluminium conductors to replace same have conductivity of 375,000 reciprocal ohms, specific gravity 2.60, specific heat 0.230; cost of round bars 30 cents per pound.

Required:

(1) The cross-sectional area of the conductors of copper which will give the minimum cost of power and interest on the investment.

(2) The same for aluminium.

(3) The running temperature of the conductors of copper above the room temperature.

(4) The same for aluminium.

Solution:

(1) Let S = cross section of conductor, in sq. cm.

Resistance of copper conductor

$$0.00000167 \times (300 \times 100) \div S = \frac{0.0501}{S} \text{ ohm.}$$

Power expended in the conductor:

$$\frac{0.0501}{S} \times (4{,}000)^2 = \frac{801{,}600}{S} \text{ watts.}$$

Cost of power thus expended, per year

$$\frac{801{,}600}{S} \div 1{,}000 \times 50 = \frac{40{,}080}{S} \text{ dollars.}$$

Weight of copper in conductor:

$$(300 \times 100) \times S \times 8.9 \div 1{,}000 = 267.\ S \text{ kilograms.}$$

Cost of conductor, if round

$$267.\ S \times 0.18 \times 2.205 = 106.\ S \text{ dollars.}$$

Interest on cost of conductor, at 10% $= 10.6 \times S$ dollars.

Sum of cost of power and interest on investment:

$$\frac{40{,}080}{S} + (10.6 \times S)$$

Solving for S a minimum, we find $S = 61.5$ sq. cm. (1)

Total costs, substituting S above

= \$652 (for power) + \$652 (interest) = \$1,304 per year.

(2) Resistance of aluminium conductor

$$0.00000267 \times (300 \times 100) \div S = \frac{0.0801}{S} \text{ ohm.}$$

Power expended in the conductor

$$\frac{0.0801}{S} \times (4{,}000)^2 = \frac{1{,}281{,}600}{S} \text{ watts.}$$

Cost of power thus expended, per year

$$\frac{1{,}281{,}600}{S} \div 1{,}000 \times 50 = \frac{64{,}080}{S} \text{ dollars.}$$

Weight of aluminium in conductor

$$(300 \times 100) \times S \times 2.6 \div 1{,}000 = 78.\ S \text{ kilograms.}$$

Cost of conductor, if round

$$78.\ S \times 0.36 \times 2.205 = 62.\ S \text{ dollars.}$$

Interest on cost of conductor, at 10% $= 6.2\ S$ dollars.

Sum of cost of power and interest on investment

$$\frac{64{,}080}{S} + 6.2 \times S$$

Solving for S a minimum $S = 101.2$ sq. cm. (2)

Total costs, substituting S above

\$633 (for power) + \$627 (interest) = \$1,260 per year

(3) Power expended in copper conductor

$$\frac{801{,}600}{61.5} = 13{,}035 \text{ watts}$$

Heat generated in conductor, per second

$$13{,}035 \times 0.2389 = 3.114 \text{ gm. cal.}$$

Area of conductor surface

$$(300 \times 100) + 3.14 \sqrt{61.5 \div 0.7854} =$$
$$= 30{,}000 + 27.8 \text{ (cm. circumference)} = 834{,}000 \text{ sq. cm.}$$

Loss of heat per second by contact with still air, per 1° difference

$$0.000056 \times 834{,}000 = 46.7 \text{ calories.}$$

Rise of temperature, excluding radiation loss

$$3{,}114 \div 46.7 = 67°.$$

The radiation loss must, however, be considered. From copper it is 0.00008 gram calories per second per sq. centimeter, if the surroundings are at 0° and the hot body at 100°, this is approximately 0.0000068 gram calories per each degree in this range. We have the combined conduction and radiation losses per 1° per second

$$0.000056 + 0.000007 = 0.000063 \text{ calories}$$

and the rise in temperature of the conductor

$$3{,}114 \div (0.000063 \times 834{,}000) = 59°.$$

The conductors would therefore run at a temperature of

$$20 + 59 = 79° \text{ C.}$$
$$= 174° \text{ F.} \qquad (3)$$

A correction of the second order would be to take into consideration the fact that at 79° the copper would have less conductivity than at 20°, its resistivity at 79° being

$$0.00000167 \times \frac{273 + 79}{273 + 20} = 0.0000020 \text{ ohm.}$$

This would make the required section for minimum expense 68 sq. cm. instead of 61.5, and would, by increasing the surface, make a different rise in temperature. The power expended would be the equivalent of 3,373 gram calories per second, and the revised temperature of the conductor would be

$$(3{,}373 \div 52.54) + 20 = 64 + 20 = 84° \text{ C.}$$

(4) Power expended in the aluminium conductor

$$\frac{1{,}281{,}600}{101.2} = 12{,}665 \text{ watts.}$$

Heat generated in conductor, per second

$$12{,}665 \times 0.2389 = 3{,}026 \text{ calories.}$$

Area of conductor in square centimeters = 1,074,000 sq. cm.

Conduction and radiation losses, per 1°

$$(0.000056 + 0.000010) \times 1{,}074{,}000 = 70.88 \text{ grm. cal.}$$

Rise in temperature of conductor

$$3{,}026 \div 70.28 = 43°.$$

Working temperature of conductor

$$43 + 20 = \mathbf{63}° \text{ C.} \qquad (4)$$

The aluminium conductor thus is seen to work cooler than the copper, and to admit of a lower minimum of working costs.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

Vienna Meeting of the Iron and Steel Institute.

Since abstracts of the papers presented at the Vienna meeting of the Iron and Steel Institute have already been published in the October issue of this journal, the following is simply an account of the proceedings and of the discussions which took place at the meeting.

Owing to the excellent arrangements which had been made by the local executive committee of Vienna the meeting was a full success. The first session was held on the 23d of September, in the building of the Society of Austrian Engineers and Architects. Mr. W. Kestranek, as the chairman of the local committee, extended in English the welcome of his Austrian colleagues to the visiting Institute. He presented to the President of the Institute, Sir Hugh Bell, a gold medal as a remembrance, and referred to the fact that his father, Sir Lowthian Bell, had occupied the chair at the former meeting of the Institute in Vienna twenty-five years ago.

Other speeches of welcome were made by the Austrian Minister of Commerce, Dr. Fort; by the Vice-Mayor of Vienna, Dr. Neumeyer, and by Prof. Klaudy, who spoke for the Society of Austrian Engineers and Architects. Sir Hugh Bell, in his reply in German, expressed the thanks of the Institute.

The first paper was presented by W. Kestranek, on the Austrian Iron Industry (see abstract on page 393 of our October issue). The paper was briefly discussed by Sir Hugh Bell, Mr. W. H. Beckley and Mr. Selby-Bigge. The latter referred to the great progress which has been made in Austria in the use of electric power in the iron and steel mills. The Institute had come to Austria to see the first application of electric power to the driving of rolling mills. Sir Hugh Bell thought that opinions might differ concerning the necessity of protecting the growth of the iron and steel industry behind import duties.

The next papers read were on the Erzberg of Eisenerz, by Prof. H. Bauerman, and on steel and meteoric iron by Prof. Fred. Berwerth. The extended discussion of the latter paper turned chiefly around the magnificent collection of the meteorites in the Imperial Museum of Natural History in Vienna, which is the finest collection of its kind in Europe. Mr. C. Johns had visited the museum and inspected the collection, being interested in the subject as a manufacturer of special steels, and he stated that this inspection of the samples had revealed many novel points to him. In the meteorites he had found structures of which only faint traces are found in commercial steel. The special feature influencing the production of these structures seemed to be that the cooling of the meteorites took place with such an extreme slowness as cannot be approached in the commercial manufacture of steel. Mr. Stead also advised members interested in special steels to study the meteorites carefully. He had been unsuccessful in his attempts to reproduce in the laboratory structures in steel such as found in meteorites.

Prof. J. von Ehrenwerth's paper on the determination of blast-furnace gas (abstracted on page 394 of our October issue) was also discussed at some length. Mr. Greiner, well known through his long activity in this field, objected to some figures in the paper. He had never found 15 per cent of carbonic acid in the gases emitted from blast furnaces working with coke. He found the CO_2 was never more than 9 per cent. The Cockerill Co. based their calculations on Lürmann's tables, which give 5,261 cubic meters per ton of carbon. On the other hand, the author had 2,954 cubic meters per ton of iron, corresponding roughly to 4,600 cubic meters per ton of carbon, while instead of the 878 calories of the author, he used 925.5 calories.

Prof. von Ehrenwerth, in reply, said that the best results with respect to the utilization of the gases are obtained if the blast furnace does not work to the greatest advantage with respect to the production of pig iron. But for the sake of the latter one has to be satisfied with a low quality of gas. Sir Hugh Bell said that there is a certain discrepancy between the demands of the blast furnace and those of the other sections of the works needing gas power. He trusted that the blast furnace would always carry the victory. It was impossible to have it both ways, and the quantity of fuel per ton of iron was the key to the whole situation. Mr. Greiner remarked that pig iron producers should not be criticised for using more fuel than given by the author in the paper. While the author's figure is 74 kg. per 100 kg. of metal produced, the Cockerill Co. uses 105 kg., and then they have 925.5 calories per cubic meter of gas instead of the author's 878. This is as well as may be wished.

Mr. C. E. Stromeyer's paper on the ageing of mild steel (abstracted on page 395 of our October issue) was the first

paper presented on Oct. 24, and was discussed at length. Sir Hugh Bell remarked that with this paper the author had thrown a bomb into the meeting, and various speakers doubted the results. Mr. Stromeyer did not think that his figures should cause any alarm, and urged steel manufacturers to repeat the test which he has developed.

Mr. B. H. Thwaite's paper on the distribution of electric power from blast furnaces brought out some remarks by Mr. Greiner. A system of the kind suggested by the author has been in practical operation for many years in the Cockerill works. There the cost of the electric kilowatt-year, including everything, amounts to $16.00. Pooling as suggested by the author is an easy thing in Germany with its military education, while the English character would not be equally suited to it.

The balance of the week was spent in various excursions and visits.

The Position of the Scottish Cyanide Co., Ltd.

I regret to state that the directors of this company have issued a circular to the shareholders, stating that, as it is practically imposible to produce cyanide with profit at its present low figure, the directors have been compelled to close down the furnaces, and recommend the shareholders to place the company in voluntary liquidation. Unsuccessful efforts have been made to dispose of the works as a going concern. The directors attribute their difficulties to the high price of coal.

Market Prices During September.

Sulphate of ammonia has risen during the month from £11.15 to £12 per ton. Copper sulphate has fallen from £27 to £24 per ton.

As regards copper, the price on September 1 was £75 per ton, irregularities occurred until the 6th, from which date the price fell steadily, until on the 16th the low price of £63.10 per ton was touched, followed by a rise to nearly £67 on the the 17th, remaining nearly steady, until the 20th it commenced to fall again, touching £64 on the 24th, a rise followed to £66.5 on the 26th, the price closing at £64 per ton.

Tin opened at £165.15 per ton, rising to £168 on the 4th, it fell to £166.5 on the 8th, rose to £167.18 on the 9th, at which figure it remained until the 10th, falling again to £159.15 on the 13th, it rose to £169.10 on the 23d, and fell to £160.10 on the 30th.

Lead has shown a steady rise throughout the month, opening at £20 and closing at £21.15.

Cleveland pig iron fell towards the middle of the month, but rose again at the end, the opening price being 50s. 8d., and closing price 55s. 10½d. per ton.

Hematite also shows a fall during the first ten days of the month, opening at 78s. and falling to 75s. 6d. on the 10th, after which it remained very steady, closing at 75s. 4½d. per ton.

The price of antimony is from £43 to £45 per ton.

London, Oct. 7.

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

Electric Furnaces.

Oxides as Resistors. B. Saklatwalla (*Zeit. f. Elektrochemie*, Aug. 30) proposes to employ oxides, such as used as filaments in the Nernst lamp, for resistors in electric furnaces. Since they become conductors only at high temperatures they must be preheated. For this reason he has devised a furnace in which the temperature is raised step by step. The lowest range of temperature is obtained by means of nickel; the next range by tin oxide SnO_2, since its resistance decreases very regularly and slowly with temperatures increasing above 600° C.; and the highest range of temperature by means of magnesia, which begins to become a sensible conductor above 1,500° C. The construction of his first experimental furnace is as follows: Compressed stannic oxide powder is finely stamped into the space between two concentric quartz tubes, electric connections being made at both ends by means of platinum rings. A nickel wire is wound around the outer quartz tube and is protected against oxidation by a thick layer of kieselguhr and a fire-clay cylinder. A magnesia tube is inserted into the inner quartz tube, and is connected to the electric circuit by means of two platinum-iridium wires. The following trouble was experienced with this arrangement. Since the tin oxide was enclosed air-tight between the quartz tubes, the tin oxide gases which formed could not escape, and there resulted the formation of hollow spaces within the stamped mass and the current was interrupted. The author intends to make a coherent dense tin oxide cylinder by pressing and burning, so that the quartz tubes are unnecessary.

Electrolytic Production of Caustic and Chlorine.

Diaphragm Cell.—In the laboratory of the University of Geneva extended studies have been carried out in recent years, under the direction of Prof. Guye, on the theory of sodium chloride electrolysis; accounts of this work may be found in *Journal de Chemie Physique*, Vol. I., pp. 121 and 212; Vol. II., p. 79; Vol. IV., p. 222; Vol. V., pp. 528 and 547. A further contribution to the same subject from the same laboratory is published by E. Briner in the same journal, Vol. V., p. 398 (July 31, 1907). The author has investigated the special part played by certain factors, especially the presence of hypochlorous acid. He has determined experimentally, as function of the number of coulombs passed through the diaphragm cell, the quantities of all substances which are present or formed, namely: Cl, HOCl, NaO_3Cl, NaOCl, NaCl, O_2 in the anode compartment, and NaOH, NaOCl, NaO_3Cl and NaCl in the cathode compartment. In confirmation of the theory, the efficiency of chlorine evolution is in the beginning smaller than the efficiency of caustic soda formation (on account of the hypochlorous acid), but with progressing electrolysis the two efficiencies tend to become equal. Finally, the author has confirmed a formula of Guye which permits the determination of the caustic soda formed as function of the coulombs passed.

Fixation of Atmospheric Nitrogen.

Nitric Acid from Air by Means of Discharges.—A useful summary of the numerous patents which have been granted in recent years in different countries in this field is given in a series of articles by H. Danneel in *Zeit. f. Elektrochemie*, March 1, May 3, 10, 17, 24, 31. Theoretically, as high a temperature as possible would be the best one, but in practice it must be taken into consideration that the higher the temperature the greater the cost of producing it and the greater the loss due to dissociation of the formed nitrogen oxide during cooling. It is estimated that 3,500° to 4,000° C. would be the best practical temperature for the formation of nitrogen oxide. The speed of the dissociation of the formed NO is high at the higher temperatures, but becomes negligibly small at about 1,500° C., so that it is necessary to cool the formed NO quickly

down to 1,500° C. Instead of using oxygen and nitrogen in the proportions in which they are contained in atmospheric air, better yields are obtained from mixtures containing oxygen and nitrogen in equal proportions by volume; according to Lovejoy, an addition of hydrogen (less than 10 per cent by volume) is advisable. Ostwald recommends to add argon (10 per cent) or helium to the gas mixture, since the electric discharges then require less voltage. The use of various electric systems for operating the arc is patented by Badische Anilin and Soda Fabrik, among them the use of polyphase currents for producing a deviated arc in rapid rotation. The Salpetersaure Industrie Gesellschaft uses the arrangement

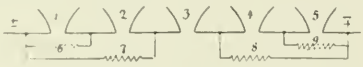


FIG. 1.—METHOD OF CONNECTION OF ARC GAPS.

shown in Fig. 1 for quickly lighting a number of arcs in series without the use of inductance coils, etc.; 1, 2, 3, 4, 5 are five-arc gaps; 6, 7, 8 and 9 high resistances. When the circuit is closed, the whole voltage is impressed on the terminal of gap 3, and the arc 3 is started; then 2 and 4 follow, etc. The resistances 1 to 6 may be made so large that during operation not more than 0.5 per cent of the flame energy is lost in the same. The summary of patents on the production of sparks and arcs given in the article seems to be very complete. It begins with the oldest patents (Mme. Lefebvre, French patent 1 045, April 26, 1859; G. Prim, German patent 20,722, March 15, 1882; Siemens-Halske Co., German patent 85,103, 1894). Numerous diagrams are added. To cool the formed nitrogen oxide quickly, either a blast of air or of steam is used, or in order to prevent the dilution of the gas mixture, the hot gas is cooled by portions of the gas which have already been cooled. The cooling process should have, of course, no effect on the active arc zone. The electrodes are usually made of

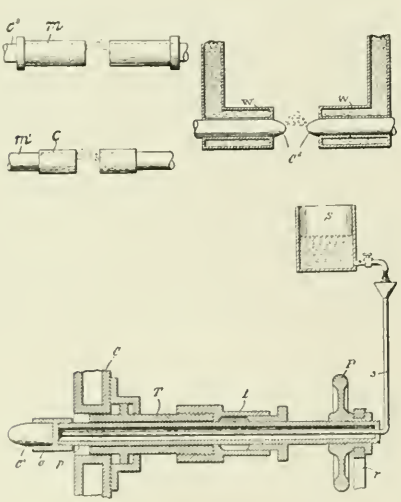


FIG. 2.—CONSTRUCTION OF ELECTRODES.

carbon, which are impregnated with metallic salts or have a core of metallic salt. A strong arc of low resistance is obtained with carbons containing 30 per cent fluorspar. The formation of CO from the carbon diminishes the output, since it reduces the nitrous gases. Fig. 2 shows four constructions of electrodes which are said to have proven satisfactory. The diagram in the upper left-hand corner shows electrodes with a core *c* of a metallic salt, surrounded by a tube *m* of carbon. By bringing the carbons into contact the arc is started. The core of the metallic salt then gets hot and begins to conduct when the carbon tubes *m* are drawn back. In the diagrams right below this the outer tube is made of the metallic salt, and the inner core, which is removable, is of carbon. The other two diagrams show methods of cooling from the outside and inside respectively. Cooling is necessary with metallic electrodes. Numerous patents have been taken out concerning regulating the proportions of nitrate and nitrite formed. Eyde and Birkeland use treatment with ozone to change nitrites into nitrates. The Westdeutsche Thomas Phosphatwerke have a catalytic process of forming ammonia from a mixture of NO and H_2 in contact with platinum black. The process is aided by dark discharges. The temperature must not rise over 80° C. Instead of hydrogen, water-gas or Dawson gas may be used.

In a paper by W. Nuranen and M. Le Blanc in *Zeit. f. Elektrochemie*, June 7, the question is brought up whether the nitric-oxide concentration which is obtained in a vessel with a high-tension arc can be calculated from the nitrogen and oxygen concentration in the gas mixture under treatment according to the law of mass action. "No chemist will deny that the law of mass action is valid for the combustion of nitrogen at a constant temperature. But it is another question whether the mass-action law is also valid for an electric flame, *i. e.*, with an arrangement with a temperature drop." On the basis of experiments this question is answered in the affirmative, and this result is rendered theoretically plausible on the assumption of a monomolecular reaction. This assumption is therefore believed to be correct at the high temperatures in question.

A. Grau and F. Russ give in *Zeit. f. Elektrochemie*, June 21, the results of experiments on the electric-flame arc in various gases: nitrogen, air, oxygen, carbon dioxide, hydrogen, carbon monoxide, sulphur dioxide. For each gas the variations of voltage with current was determined. The same authors give in *Zeit. f. Elektrochemie*, Aug. 23, an account of experiments proving the validity of the law of mass action in the oxidation of atmospheric nitrogen. According to this law, the yield of nitrogen oxide becomes greater if a mixture of nitrogen and oxygen, richer in oxygen than atmospheric air, is used.

Calcium Cyanamide.—A second method of fixation of atmospheric nitrogen is by passing nitrogen over calcium carbide at an elevated temperature whereby calcium cyanamide is formed. Now, it is a peculiar fact that if pure calcium carbide is used the desired reaction with nitrogen will not take place. But commercial calcium carbide contains some calcium oxide, and, according to Frank and Caro, this amount of impurity is sufficient to enable the carbide to combine with the nitrogen at 1,100° C. The nitrogen gas must be free from oxygen, probably because the latter would oxidize the cyanamide with great facility. Neither is producer gas suitable instead of nitrogen, because the CO contained in it would react with the carbide at red heat under formation of burnt lime. The addition of other impurities suggested itself, and it was indeed found that an addition of 10 per cent of $CaCl_2$ has the effect that the combination of the calcium carbide with the nitrogen occurs at a temperature several hundred degrees lower than without the calcium chloride. A temperature of 800° C. is here sufficient. Calcium fluoride acts in a similar way; according to Carlson an addition of 10 per cent of this salt has the effect that the reaction between the carbide and the nitrogen takes place at a temperature of 900° C. Furthermore, according to Carlson, the fluoride is better, because the cyanamide thus produced is not hygroscopic.

The reason why these additions are useful has been the subject of independent investigations by Foerster and Bredig. F. Foerster and H. Jacoby in *Zeit. f. Elektrochemie*, March 22,

show that the addition must remove some obstacle which prevents the progress of the nitrogen absorption. They make it probable that when a lump of carbide reacts on its outer surface with nitrogen this outer surface changes into cyanamide and forms a cover which prevents the nitrogen from reacting with the carbide inside. The addition of calcium chloride (melting point below 800° C.) has probably the effect to liquify or soften this cover, so that the nitrogen can react freely with the carbide below the cover.

G. Bredig, in *Zeit. f. Elektrochemie*, March 1, shows that various other hypotheses which have been proposed to explain the effect of the additions are untenable. In a second paper by G. Bredig, W. Frankel and E. Wilke in *Zeit. f. Elektrochemie*, Sept. 6, they apparently accept the explanation of Foerster, but point out that the melting point of the addition is not the only determining factor. It is necessary to take into consideration the fusion diagram of the total reaction mixture, the solubility of the carbide in the fused bath and the specific total reaction velocity constant in the fused bath. Other things being equal the speed of the absorption of nitrogen is porportional to the pressure of the nitrogen gas within the limits investigated. Of all additions which were tried by these authors the chlorides were found to be the best ones, and among these calcium chloride was most effective.

Argon from Air.—In connection with this matter it is interesting to note a method of F. Fischer, E. B. Maxtet and G. Iliovici in *Zeit. f. Elektrochemie*, March 22, for making argon from air. Calcium carbide containing 10 per cent of calcium chloride is heated in a retort to 800° C., and pure dried atmospheric air are introduced. The oxygen and the nitrogen are absorbed and there remains nothing but argon and the other noble gases.

Action of Electric Spark at Low Temperatures.—An account of experiments by E. Briner and E. Durand is given in *Comptes Rendus*, 1907, Vol. 145, p. 248, and abstracted in the *Journal* of the Society of Chemical Industry, Aug 31. Electric sparks were passed through dry air at atmospheric pressure at the ordinary temperature, at the temperature of solid carbon dioxide and ether (— 80° C.), and at that of liquid air (— 190° C.), and the amount of nitrogen peroxide formed was estimated from the diminution of pressure. The limiting concentrations reached were respectively 5 to 6, 10 to 15 and 20 per cent, the last corresponding to the complete fixation of the oxygen. Experiments with the vessel immersed in liquid air, and containing in different series mixtures of 4 vols. of nitrogen to 1 of oxygen (air), equal volumes of the two, and 1 vol. of nitrogen to 2 of oxygen, showed that in all cases the ultimate product was nitrogen peroxide. But there is evidence in favor of the view that the spark forms primarily nitric oxide, which is then oxidized in the first place to the trioxide and ultimately, after a longer period, to peroxide. It appears that the fixation of nitrogen as oxide gives better yields than its fixation as ammonia.

Ozone.—An illustrated summary, by Kausch, of recent patents on the production of ozone by electric discharges, is published in *Elektrochem. Zeit.*, June, July and August.

Edison Storage Battery.

Potassium Hydrate. The transference numbers of the ions of concentrated potassium hydrate, which must be known for an exact calculation of the ionic migration phenomena in the Edison nickel-iron battery, have been determined by G. Nordström (*Zeit. f. Elektrochemie*, Feb. 1). His mean value for the transport number of the cation (K) is $1 - n = 0.221$.

Iron Electrode.—The chemical reactions at the iron electrodes have been studied by O. Faust (*Zeit f. Elektrochemie*, April 26), who determined complete charge and discharge curves of an iron electrode in a 20 per cent K O H solution against a hydrogen electrode. The discharge curve shows three steps. The "active material" in the first step is hydrogen occluded in the iron during the charging process. In the second step the active material is pure iron, free from hydrogen. In the further discharge the iron must be changed into one of its oxides; it is probable that it changes into Fe_2O_3 or its hydrate.

Nickel Electrode.—A very extended investigation of the Edison battery has been made by F. Foerster, and his results concerning the phenomena at the nickel electrode are given in a paper in *Zeit. f. Elektrochemie*, July 12. When nickelous hydroxide, $Ni(OH)_2$, is charged as anode in potassium hydrate it absorbs more oxygen than corresponds to the formation of Ni_2O_3. As a matter of fact, anodic oxidation of $Ni(OH)_2$ first yields NiO_2, which spontaneously changes later into Ni_2O_3. Accordingly, the charging potential soon rises above the potential of Ni_2O_3. The product of the electrolytic oxidation of $Ni(OH)_2$ is a monophase homogeneous system, presumably a solid solution of NiO_2 in Ni_2O_3. Left alone, it changes spontaneously into Ni_2O_3, with simultaneous change of the potential. A freshly charged nickel electrode has therefore a greater capacity than one which has been at rest for some time after charging, the chief loss of capacity occurring during the first 24 hours after completed charge. When a freshly charged nickel electrode is discharged, the NiO_2 is first reduced, then follows the reduction of Ni_2O_3, and then the reduction of an oxide lower than Ni_2O_3. The reactions during discharge are not the exact reverse of those during charge. The ampere-hour efficiency during charging is almost theoretical for a certain length of time; after the electrode has thus assumed the principal part of its capacity (which is the more the less the current density), the ampere-hour efficiency decreases quickly and rapidly; but in spite of that it is possible to increase the capacity of the electrodes quite considerably still further.

Various Electrochemcal Processes and Experiments.

Electrolysis of Fused Salts.—An important paper by R. Lorenz in *Zeit. f. Elektrochemie*, Aug. 23, refers to the well-known fact that the efficiency of electrolysis of a fused salt of a heavy metal can be very considerably increased by the addition of a salt of an alkali. Such additions have often been recommended and used by practical men in the past, but Lorenz's paper throws an absolutely new light on the rationale of their effectiveness. Lorenz had formerly found that one of the principal phenomena which diminish the efficiency is the formation of a mist or fog or schliere from the fused cathode. Thus in the electrolysis of fused lead chloride with a fused lead cathode, lead goes back into the fused lead chloride bath in form of a mist, which travels over to the anode and there recombines with the anion (in this special case, chlorine), thus undoing the useful work of electrolysis. Lorenz and Helfenstein had formerly found that the migration of the mist toward the anode could be counteracted by separating or enclosing the electrodes by diaphragms, such as perforated glass or porcelain vessels. But he found later that in the case of electrolysis of lead chloride, the simple addition of potassium chloride prevented the mist formation, and was just as effective in increasing the efficiency as the use of a diaphragm. He has now established the fact that this is a general expedient. The efficiency of electrolysis of lead chloride is greatly improved by adding either potassium chloride or sodium chloride or barium chloride; similarly the electrolysis of lead bromide by adding potassium bromide, the electrolysis of cadmium chloride by adding potassium chloride or sodium chloride, etc. In all cases the effect of the addition is to prevent the formation of the cathodic mist. Why the formation of mist is thereby prevented is not yet quite clear, but the following experiment may perhaps indicate the reason. If we have no electrolysis at all, but a fused bath of lead chloride, containing a mist of lead so as to be not transparent, then the simple addition of some potassium chloride suffices to precipitate the mist, and the fused bath becomes transparent. This phenomenon reminds one

directly of the precipitation of colloids by addition of electrolytes

Artificial Diamonds.—In London *Electrical Engineering* of Sept 20, we note a French patent, 375,669, granted to L. Bonnet, and relating to a method of obtaining amorphous, fused or black diamond. The process consists in fusing carbon with a high-tension electric current in a liquid or gaseous medium under high pressure. The apparatus consists of a thick vessel of bronze or any other suitable metal, containing two thick carbon electrodes, between which is placed a piece of pure rod carbon. Underneath this rod there is a dish containing carbon disulphide or other liquid which has no action on carbon and which will readily evaporate and produce a high pressure. A current sufficient to evaporate the carbon disulphide is first passed, and when the pressure is sufficiently high a heavy current, which fuses the carbon, is passed for a few minutes. The pressure may also be produced within the vessel by forcing an indifferent gas into the apparatus by mechanical means. In this connection reference should be had to an account by C. A. Parsons in the September issue of the *Proceedings* of the Royal Society of some recent experiments made by him on the effect of heating carbon electrically to a very high temperature and under strong pressure. The main conclusions to be drawn from his experiments are that at very high temperatures and pressures carbon is still a very good conductor, and that soft crystalline graphite is the resulting stable form of carbon after this treatment. Further, there has never been formed more than a suspicion of black or transparent diamond, and the inference is, therefore, that mechanical pressure is not the cause of the production of diamonds in rapidly cooled iron.

Carbon Crucible.—E. Mueller describes in *Zeit. f. Elektrochemie*, March 22, the simple form of carbon crucible for high-temperature experiments, shown in Fig. 3. The conical carbon crucible is sawed vertically through into two halves and is inserted with its bottom into the closely fitting central hole of a carbon block which is placed on a metal sheet connected to

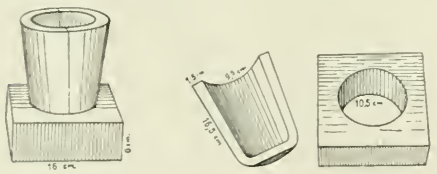


FIG. 3.—CARBON CRUCIBLE.

one pole of the circuit. A carbon rod introduced at the top is connected to the other pole. The advantages of this construction are that it is cheap and permits taking the crucible into parts after the conclusion of the experiment.

Electrolysis of Sulphuric Acid.—In the *Zeit. f. Elektrochemie*, May 31, there is a long paper by E. Mueller and H. Schellhaas on the part which oxysulphuric acid (Caro's reagent) plays in the electrolytic production of persulphuric acid and its salts. For the production of persulphates on a commercial scale it is at present necessary to use a diaphragm cell in order to prevent part of the persulphate formed at the anode from being again reduced at the cathode. For the continuous production of persulphate it is not only necessary that the oxysulphuric acid is destroyed by chemically active additions, but that the persulphate formed is rendered only difficultly soluble. For sodium persulphate production this may be accomplished by the use of concentrated solutions of sodium sulphate containing considerable free sulphuric acid.

Electrolysis of Fused Sodium Nitrate.—A paper by Ch. Couchet and G. Nemirowsky in *Zeit. f. Elektrochemie*, March 20, deals with the electrolysis of fused sodium nitrate under varying conditions. The sodium nitrate is reduced to nitrite at the cathode, while at the anode sodium oxide is formed and various gases are given off. The best yield of nitrite is obtained with graphite electrodes, and the formation of nitrite increases with increasing temperature, with increasing current density and decreasing voltage. The graphite deteriorates the more the higher the temperature and the current density.

Alternating-Current Electrolysis.—Ch. Couchet and W. Chauffat (*Zeit. f. Elektrochemie*, July 12) have studied the electrolysis of sodium nitrate solutions by alternating current. They investigated the effect of current density, concentration, duration of experiment, temperature and frequency. With respect to frequency they obtained in all cases a maximum efficiency at 47 periods.

Electrolytic Rectifier.—J. Sebor and L. Simek in *Zeit. f. Elektrochemie*, March 29, describe some experiments with the aluminium rectifier. The purity of the aluminium appears to be of great influence on the critical voltage. But this influence manifests itself in a different way according to the nature of the electrolyte. If the impurity is present in small quantity only, and shows itself a valve effect like Mg. Sb, the change in the critical voltage is not great.

Electroanalysis.—Evidences of the indefatigable work of Prof. E. F. Smith at the University of Pennsylvania are the following papers, all published in the April issue of the *Journal* of the American Chemical Society: Joel H. Hildebrand, on the determination of anions in the electrolytic way; Anna L. Flanigen, on the electrolytic precipitation of copper from an alkaline cyanide electrolyte; Julia Langness, on electrolytic determination and separation with the use of a rotating anode; L. F. Witmer, on the determining of tin with rotating anode; while the June issue of the *Journal* contains a paper by Lily G. Kollock and E. F. Smith, on the effect of sulphuric acid on the deposition of metals when using a mercury cathode and rotating anode. Of other contributions to electroanalysis the following may be noted: L. T. Sherwood and G. Alleman, in the July issue of the *Journal*, on the use of tin as a cathode for the rapid quantitative electrolytic deposition of zinc, copper, silver, cadmium and nickel, and the following German papers, all of which are published in the *Zeit. f. Elektrochemie:* A. Classen, on several devices for rapid electroanalysis (May 3); F. C. Frary, on a method of stirring the electrolyte for shortening the time of analysis by electromagnetic means similar to Ashcroft's method of stirring a fused lead bath (June 7); A. Fischer, on rapid electroanalysis under observation of the electrode potentials (July 26); N. A. Puschin (April 19), on separation of tin from manganese, iron and chromium; F. Foerster and J. Wolf (May 10), and H. J. S. Sand (June 14), on determination of antimony; A. Fischer (June 28), on determination of nickel from ammonium oxalate solutions.

Physiological Effect of Alternating Current.—Nernst has developed the hypothesis that the physiological effect of the electric current on organic tissues is due to ionic migration, resulting in concentration changes. As soon as the concentration change attains a certain value the first perceptive physiological effect, the irritation of a muscle or a nerve occurs. On the basis of further theoretical considerations, Nernst found a formula according to which the electric irritation of organic tissues by alternating current is proportional to the square root of the frequency, at least as long as the frequency is very low. E. Reiss (*Zeit. f. Elektrochemie*, July 26) has experimentally confirmed this formula for frequencies between 30 and 3,500.

Valency of Silver.—E. Bose (*Zeit. f. Elektrochemie*, July 26) briefly discusses the chemical facts which indicate the existence of silver salts with the valency one-half, and then describes a method of demonstrating experimentally the equilibrium $Ag + Ag^{\cdot} \rightleftarrows Ag_2^{\cdot}$.

Passive State.—In a brief note on the passive state of iron in *Zeit. f. Elektrochemie*, June 7, F. Haber and W. Maitland call attention to several recent observations on the behavior of iron in alkaline solutions, which, in their opinion, can be explained only on the basis of the oxide theory of the passive state of iron. In a note in *Zeit. f. Elektrochemie*, Sept. 6, R. Lohnstein refers to the passive state of magnesium in dilute acetic acid containing some potassium dichromate. Magnesium does not dissolve in this solution except when it is made anode in an electric circuit.

Niobium.—Werner von Bolton, well-known through his work on vanadium and tantalum and the development of the tantalum lamp, has studied the element niobium. He gives his results in *Zeit. f. Elektrochemie*, April 12. He believes to be the first who has produced pure niobium by two methods; one is to produce by the Goldschmidt aluminothermic method an alloy of Nb and Al and to purify this in the flame arc of an electric vacuum furnace until the total aluminium is evaporated. Pure niobium is a half ductile and chemically very noble metal. How difficult it is to produce it pure, appears from the necessity of remelting it about 200 times in vacuo in order to remove all impurities.

Tantalum.—According to M. von Pirani, *Zeit. f. Elektrochemie*, June 21, the specific resistance of pure tantalum is 0.146, with a temperature coefficient of 0.33 for temperatures between 0° and 100° C.

Determining the Melting Point of Metals.—For the determination of the melting point of metals and alloys and for the calibration of thermoelements by fixed points, the molten metal is generally placed in a crucible and by means of a thermoelement, which is protected by a porcelain tube, the temperature is determined. While the fused metal cools and passes into the solid state, the temperature remains constant for some time, and this is the solidification point. This method has the disadvantage that it requires a relatively large quantity of the metal which is molten. For valuable metals, Berthelot has developed another method in which the metal is used in form of a short wire, and this method has been modified by Holborn and Day as follows: The metal wire, the melting point of which is to be determined, is inserted in the thermoelement itself, being connected between the ends of the thermoelement wires. By this method the point is determined at which the needle of the galvanometer returns to the zero point, on account of interruption of the thermocurrent, due to the melting of the wire. But this method has the disadvantage that it cannot be applied to oxidizable metals, the melting point of which depends on the surrounding atmosphere. R. Loebe (*Zeit. f. Elektrochemie*, Aug. 30) recommends to use two separate circuits; one contains the thermoelement, the other the wire whose melting point is to be determined in series with a battery and an electromagnetic device, by means of which a signal is given when the circuit is broken. The wire to be melted and the hot junction of the thermoelement are placed very near together in a closed crucible, which may contain any gas atmosphere or a molten salt, etc. The crucible is heated, and when the signal indicates the melting of the testing wire, the galvanometer is read. L. Holborn (*Zeit. f. Elektrochemie*, Sept. 27) remarks that the method is by no means new, but is useful for oxidizable metals and for such cases in which the optical pyrometer is used for measuring the temperatures.

Determining the Conductivity of an Electrolyte Without Electrodes.—It has long been clearly understood that to measure the conductivity of an electrolyte the influence of the electrodes must be carefully eliminated since it acts as a disturbing factor. This has mostly been accomplished by using alternating current of sufficiently high frequency. W. S. Franklin and L. A. Freudenberger (*Physical Review*, October) use a method in which no electrodes are used at all. To explain the principle it will be sufficient to describe one of their arrangements. A transformer is so built that it has one primary winding but two secondary circuits, the disposition being exactly symmetrical. One of the secondaries is formed by a ring of glass filled with the electrolyte to be tested. The transformer is essentially a three-core transformer, the two secondaries being placed on the two outer cores and the primary winding is so applied that with the secondaries cut out no flux passes through the middle core. If now the electrolyte is filled into the ring vessel, currents are induced in it by induction, and the balance of the system is destroyed, as is indicated by the fact that a flux now passes through the middle core. Balance is re-established by closing the other secondary on the other outer. The resistance of this second secondary is adjustable. Balance will exist if this resistance equals that of the electrolyte. A method operating on this principle was applied to the test of various salt solutions, and it is interesting to note that within the limits of error the results closely agree with those of Kohlrausch and Holborn.

The Nature of the Over Voltage.—In *Zeit. f. Elektrochemie*, Sept. 20, Felix Kaufler shows that an electrode, while showing the phenomenon of over-voltage (überspannung) becomes heated. At heated platinum electrodes such reactions (reductions or oxidations) which require an over-voltage, may be carried out. With increasing temperature of the electrode and with constant current density the over-voltage decreases. The action of over-voltage in electrolysis may, therefore, be explained essentially by a local heat effect of the electrode, whereby the forming products are rapidly removed from the zone of higher temperature. The hypothesis of an hydrogen or oxygen pressure of several thousand atmospheres at such electrodes becomes therefore superfluous.

Conductivity of Dilute Solutions.—In *Zeit. f. Elektrochemie*, Aug. 30, P. Bogdan tries to show that Ostwald's law for the relation between conductivity and concentration is obeyed by HCl and HNO_3, in solutions which are more dilute than 1/80 normal. But F. Kohlrausch shows in *Zeit. f. Elektrochemie*, Sept. 27, that this conclusion is not justified by Bogdan's figures.

Calcium.—An illustrated summary of the different methods which have been proposed and used for the electrolytic manufacture of metallic calcium is given by Carl Bürgel in *Elektrochem. Zeit.*, January, February, March, April, May. All the methods discussed have been described in our columns. The author thinks the chief problem is now to find commercial applications of calcium.

Tungsten.—According to H. von Wartenberg (*Berichte*, 1907, Vol. 40, p. 3,287) the melting point of pure tungsten is between 2,800° and 2,850° C.

Ionic Mobilities.—In *Zeit. f. Elektrochemie*, March 8, K. Drucker calculates new values of the mobilities of various ions in aqueous solutions on the basis of recent determinations of transport numbers. The results are given in the column marked Drucker, while the older values of Kohlrausch are given below for comparison:

	K.	*Na.*	*Li.*	*Ag.*	*H.*
Drucker	64.4	42.7	32.4	54.0	313.0
Kohlrausch	64.67	43.55	33.44	54.02	318.
		Ca.	*Zn.*	*Cd.*	*Ba.*
Drucker		50.5	41.8	42.3	52.5
Kohlrausch		51.46	46.57	47.35	55.10
		Cl	*Br.*	NO_3.	SO_4.
Drucker		65.2	66.3	62.3	66.7
Kohlrausch		65.44	67.63	61.78	68.14

A critical summary of the whole present situation of ionic mobilities is given by F. Kohlrausch in *Zeit. f. Elektrochemie*, June 21. He gives the following figures for 18° C.:

H.	*Cs.*	*Rb.*	*K.*	*Na.*	*Li.*	*Ag.*	*Tl.*
315	68	67.5	64.6	43.5	33.4	54.3	66.0
I.	*Br.*	*Cl.*	*F.*	*SCN.*	NO_3.	ClO_3.	IO_4.
66.5	67.0	65.5	46.6	56.6	61.7	55.0	33.9

Iron and Steel.

Passivity of Iron.—In connection with the electrochemical theory of the corrosion of iron, which is now attracting so much attention, a paper by Henry L. Heathcote in the *Journal* of the Society of Chemical Industry, Aug. 31, on "the passivifying, passivity and activifying of iron" is interesting. He gives a good summary of what has been done by others in this field and an account of experiments made by himself. The main fact established by him is the intimate connection between the phenomena occuring when liquids are used to passivify or activify iron on the one hand and those manifested when an electric current is employed on the other hand. The conclusion is that the process of passivifying is always electrolytic, and that when no external current is employed we have short-circuited galvanic cells, some parts of the iron surface acting as anodes and others as cathodes. "In accordance with this view, we regard the process of passivifying as occurring in the following manner: When iron is immersed in a solution, some of the metal passes into solution forming ferrous ions, or the ferrous ions in the metal pass into the solution from all parts of the surface. The solution pressure of the iron will not be the same at all parts of the surface, * * * consequently, local electric currents will arise, and if the solution will act as depolarizer at the cathode of the local current, the current may persist until it effects passivification of the iron at the local anode. In this way a number of very small local cathode areas might be associated in the passivification of a much larger local anode area, and the rest of the surface might become passive nearly at the same moment all over. If the solution, however, is not a very vigorous hydrogen depolarizer, or if its action on active iron is vigorous, passivifying may require quite a considerable time." As to the cause of passivity itself, the author considers that all facts are best explained by the theory which postulates a layer of magnetic oxide, Fe_3O_4. "The ions H and OH can be liberated even from aqueous solutions of salts which contain no oxygenated anions, and our results go to show that it is the ion OH which effects passivity, and it is certain that this state is due to the establishment of a solid phase." A useful bibliography on the passive state of iron is added.

Copper.

Copper Silicon.—The nature and composition of the silicides contained in copper-silicon alloys has been studied by M. Philips (*Metallurgie*, Sept. 8 and 22). The alloys were prepared from pure copper and silicon, but before the real investigation was started the following interesting experiment was made: A quantity of fine copper scrap was embedded in a large mass of finely powdered silicon crystals, and covered with a layer of common salt and heated for 5 hours to a temperature of 700 to 750° C. After cooling, the pieces of copper had retained their corners and edges as sharp as before, but had become very brittle, and the fracture showed a uniform silver-white. Analysis gave a content of 9.56 per cent Si. This shows that copper is able to absorb silicon, even below its melting point. The chief result of the author's investigations of silicon-copper alloys—which contain much of interest with respect to analytical refinements and improvements—is the proof of the existence of a copper silicide of the formula Cu_3Si_2.

Gold.

Gold from Gold-Plate Scrap.—The electrolytic recovery of the gold from rolled gold-plate scrap is the subject of an article in the September issue of *The Brass World*. In general, the quantity of gold in rolled plate scrap runs from 1.5 to 18 parts per 1,000. The usual method in smaller plants is to melt the waste in a graphite crucible, shot it by pouring into water and then part the gold and copper by means of a hot, strong sulphuric acid solution. The copper, together with what zinc is present, dissolves as sulphate, while the gold is left in form of a powder. For large plants it is far more economical to melt the waste into anodes and refine them according to electrolytic refining practice. In the article in question some advice is given how to proceed in medium plants. The anodes are best ½ to ¾ inch thick. The electrolyte is a 15 per cent solution of copper sulphate, containing 5 per cent free acid. The electrolyte is kept in circulation by means of a pump. Cathodic current density 5 to 10 amps. per square foot.

Lead.

Electrolytic Refining of Lead.—The process of Anson G. Betts for the electrolytic refining of lead has been described repeatedly and in detail in our columns. An interesting account of the practice in the plant of the Consolidated Mining & Smelting Co., of Canada, Ltd., at Trail, B. C., may be found in a paper by A. G. Wolf in the May issue of the *Western Chemist and Metallurgist*, where also the treatment of slimes and by-products is dealt with.

Nickel.

Rusting of Nickel Plate.—It is a fact of everyday experience that electrolytic nickel plate rusts on any prolonged exposure to moisture, and this rusting is pronounced to be due to small amounts of iron contained in the plate and coming from the solution during the plating process. This impurity may be conceived as constituting with the nickel a series of galvanic couples that cause rapid rusting in the presence of moisture in the air. The iron evidently comes from the impure nickel anodes to which iron is added, since pure nickel anodes would not dissolve to a sufficient degree in the commercial electrolyte of nickel-ammonium sulphate. The way in which the iron passes over from the anode to the cathode has been studied more closely by D. F. Calhane and A. L. Gammage (*Journal*, American Chemical Society, September). Using the ordinary compound anode containing about 7.5 per cent of iron, they found that the amount of iron in the nickel plate will average about 0.10 to 0.14 per cent. If the electrolyte is stirred or the electrodes rotated, the amount of the iron impurity increases very considerably. If the anodes are surrounded by bags or any suitable filtering medium, the amount of the iron impurity is cut down about one-half. Yet iron to the extent of 0.04 to 0.05 per cent will still appear in the nickel plate in spite of filtering septa, and is probably the result of primary deposition by the current. The use of bags over the anodes seems desirable, as they do not appreciably raise the voltage, and they keep the bath much clearer and decrease the iron impurity in the nickel deposit by about one-half. The total avoidance of small amounts of iron in the nickel plate does not seem possible with the anodes at present used in technical work. (It would certainly seem useful to try Dr. Bancroft's suggestion to employ pure nickel anodes and increase their solubility by adding an ammonium chloride or nickel chloride to the nickel-ammonium sulphate electrolyte).

Tin.

Electrometallurgy of Tin.—Another series of articles by H. Mennicke, on the electrometallurgy of tin, has appeared in *Elektrochem. Zeit.*, March, April, May, June, July. He first gives a review of the tin market with its high prices. Concerning detinning, he states that the treatment of tin boxes (instead of tin scrap which was formerly used exclusively) is now increasing in commercial importance; it has been introduced in various plants and the collecting and buying of old tin boxes is being systematized. In view of high prices he thinks that tin refining should pay (see the article by O. Steiner, p. 309 of our August issue). The author then gives a review of patents on the electrometallurgy of tin, granted during the last year, with critical notes. Concerning the detinning of tin boxes, he says that the preparatory treatment is more troublesome than is generally believed. It is first necessary to remove anything that is not tinned iron, such as stones, iron nails, etc. The tin boxes are then rolled so as to decrease

their volume, without compressing them completely. Perforating is said to be unnecessary. Fat oil, etc., are removed by means of a caustic soda solution; paper, etc., is carburized, and the solder is removed by treatment in a suitable furnace. Finally, after treatment by cutting and rolling machinery, the material is electrolytically detinned.

Ore Dressing.

Electrostatic Separation.—Dr. Friedr. Esser gives in *Metallurgie* Sept. 8 and 22, an account of an investigation made for the Metallurgische Gesellschaft, of Frankfort a. M., and the Maschinenbau Anstalt Humboldt, of Kalk-Cologne, to study the possibilities of electrostatic separation. In the first experiments the electric charges were produced by an electrostatic influence machine, but this was found quite impossible for any continuous operation, because the generation of electricity then depends too much on the humidity in air. The following arrangement was then used. The current from an alternator is fed to a transformer, which raises the voltage, and the high-voltage current is then supplied to a simple commutator, running synchronously with the alternator, so as to get an undirectional high-tension current. As to the construction of the separator reference may be had to the illustration of the Blake separator, our Vol. III., p. 181, although the construction used in the present experiments was somewhat different. Experiments were first made with mixtures of zinc blende and iron pyrites, and it was found that it was necessary to crush the ore at least to ½ mm. size. But even then the separated pyrite was found to contain considerable quantities of zinc. The explanation was found to be that the size of the particles was still too large; in the ore the zinc blende was very intimately united or "impregnated" with the pyrite that some particles of blende of ½ mm. size will carry some pyrite. In this way part of the blende particles become conductors and are carried over with the pyrite. In such cases zinc blende cannot be classed strictly as a non-conductor. Neither is it always correct to class galena as a conductor, since in one experiment of the author galena behaved partly as conductor and partly as a non-conductor, and was carried over in the electrostatic separation in about equal halves to the blende and to the pyrite. As a general result of his experiments the author concludes that electrostatic concentration is applicable with good success only to particles of a size between certain limits. Sizes downwards from 1 mm. to a certain minimum size were found most suitable; above 1 mm. the results were less satisfactory, while the finest powder could not be separated electrostatically. To be successful, it is necessary that each of the particles to be separated consists of the same material; any impregnation with foreign materials acts as a disturbing factor. Zinc blende should not be closely impregnated with pyrite; therefore, those zinc blendes which are poor in iron are most suitable for electrostatic separation. These conclusions, however, are valid only for countries with the same climate as Germany. In districts high above sea level and with a dry climate, as in Chili and Bolivia, the conditions are much more favorable to electrostatic separation.

Miscellaneous.

Electric Power in German Iron and Steel Works.—*Elektr. Kraftbetr. u. Bahnen* of July 24 describes the use of electric power in the Burbacher Hutte, which has two power plants. The older one contains three gas engines, operated by blast-furnace gases driving 240-volt direct current generators. The newer plant contains a gas engine, operated with coke oven gas, and a steam turbine; instead of the two-wire 240-volt system of the old plant, the three-wire 2 × 240 volt system is here used. The power is used for driving 300 motors of an aggregate capacity of 3,000 hp., for driving the rolling mills, traction and all kinds of power purposes. For lighting, 4,000 incandescent lamps and 300 arc lamps are used. In the same journal of Aug. 3, G. Meyer describes in great detail the electric charging apparatus for the blast furnaces of the iron and steel works Karl-hutte, near Diedenhofen. Detail drawings are given and the Ward-Leonard system is said to have proven very successful in all such installations made by the Siemens-Schuckert Co.

Melting Compounds of the Iron Group Elements.—The *Bulletin of the Bureau of Standards* Vol. III., No. 3, August, 1907, contains a paper by G. K. Burgess on the determination of melting points of the elements of the iron group by a new radiation method. The chief results are as follows:

Metal.	*Melting Point.*	*Purity.*
Iron	1,505° C.	99.95
Chromium	1,489	98–99
Cobalt	1,464	99.95
Nickel	1,435	99.95
Manganese	1,207	98–99

Of these, the cobalt and nickel melting points appear to be correct to within 5°, while the uncertainty of the iron, chromium and manganese points is probably less than 10° C.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Boron Carbide.—S. A. Tucker, 869,114, Oct. 22, 1907. Application filed Dec. 19, 1906. Assigned to E. A. Sperry.

The object is the production of pure massive boron carbide B_4C. It has a specific gravity of 2.7, is highly refractory and is an electrical conductor. From it incandescent filaments and high-temperature resistors, are terminals and electrodes may be made. Boron carbide is also extremely hard, harder than corundum or carborundum. The construction of the furnace is shown in Fig. 1. The mixture of anhydrous boron oxide

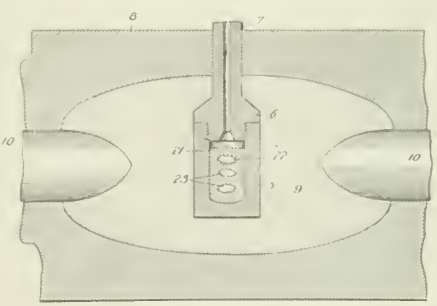


FIG. 1.—BORON CARBIDE FURNACE.

B_2O_3 and carbon in proper proportions is placed within a suitable inclosure, as the chamber 5 made of refractory substance, such, for instance, as pure graphite, and preferably capable of sustaining a pressure without undue leakage, being closed by cap 6, which is supplied with an upwardly extending stem or tube 7. This cell is placed within a cavity in an electric furnace 8, and packed with resistor material, such as carbon or boron carbide particles 9. The terminals 10, 10 lead to the secondary of a transformer. Means are provided whereby the contents of the chamber 5 are brought under desirable pressure. For this purpose the upper end of the tube 7 is provided with a suitable valve. An excess of boron is found advantageous in yielding a purer product. The mixture having been placed in the chamber is heated to a point where the boron oxide melts into a glazy and somewhat viscous mass. At this point in the operation the material has to be stirred. The tem-

perature is then raised to the point where the reaction takes place. The temperature and its distribution is important, and for some purposes it is desirable that the chamber 5 or its equivalent be somewhat elongated and that it be subjected to a non-uniform temperature, so that in this manner upon removal of the product it may be segregated into masses produced at critical temperatures. "In the same compartment, for instance, 21, I have produced crystals as 22, but I find these usually exist in this combination around cavities as 23, opening up in the mass upon cooling. I have made the discovery that crystals, regardless of their exact method of production, are larger with a definite tendency to freedom from fracture and more valuable when the cooling takes place slowly."

Treatment of Ferruginous Zinc Blende.—Woolsey McA. Johnson, 868,345, Oct. 15, 1907. Application filed Jan. 11, 1904.

Ore containing, say, 40 per cent of zinc, 20 per cent of iron, and 30 per cent of sulphur and smaller proportions of copper and lead sulphide and precious metals, is roasted at about 850° to 900° C., whereby the zinc and iron are largely converted into oxides. The roasting need not be complete, and in practice sulphur is not reduced below 3 per cent. This results in the production of a rich gas suitable for conversion into sulphuric acid. The roasted product is mixed with 35 per cent of carbon and subjected to a temperature of 850° to 950° C., whereby the iron oxide is reduced to iron sponge, while the zinc oxide is left unreduced (since it requires for its reduction a temperature of about 1,000° to 1,150° C.). The reduction of the iron oxide to iron sponge may also be effected by means of natural gas. The product of this reduction, containing, in addition to the iron sponge, a zinc oxide, sulphides of zinc, lead and copper and the precious metals with admixed carbon, is then at once subjected to such higher temperatures as are sufficient for the distillation of zinc. This is done in an electric furnace of the resistance type, the iron sponge acting as résistor. The distillation proceeds with great readiness and with but slight consumption of electrical power, because the electric furnace treatment of the charge is begun at a temperature but a few hundred degrees below that required for the reduction of the zinc. The zinc sulphide remaining in the charge is reduced by the iron according to the equation $Fe + ZnS = FeS + Zn$. The iron sulphide formed constitutes the principal constituent of a matte which is found to contain the precious metals of the original ore. The production of iron and zinc in successive steps of the process has the advantages that less electric power is required and that the zinc vapors are less diluted with inert gases, thus facilitating the condensation.

Ferro-Calcium Carbide.—J. Misko, 868,610, Oct. 15, 1907. Application filed Jan. 5, 1907.

Ferro-calcium carbide is made either by adding the proper amount of iron to the charge introduced into the calcium carbide furnace or the iron is added after the calcium carbide has been formed. Concerning its application see the abstract under Recent Metallurgical Patents.

Electrolytic Processes.

Production of Sodium, Etc.—F. von Kuegelgen and G. O. Seward, 868,670, Oct. 22, 1907. Application filed June 13, 1905.

In the production of alkali metals by electrolysis of their fused chlorides it is very important to keep the temperature of the electrolyte so low that there will be no tendency for the metal formed to dissolve in the electrolyte and when reaching the anode to recombine with the chlorine. The difficulty becomes the greater the higher the melting point of the electrolyte. It is, therefore, important to lower the melting point by suitable additions. The inventors propose to accomplish this by the addition of a fluoride, the decomposition voltage of which is higher than the decomposition voltage of the fluoride which is to be decomposed. For instance, in order to produce metallic sodium from fused sodium chloride, the inventors use sodium fluoride and calcium fluoride as the flux, and the mixture of sodium chloride and fluoride is subjected to electrolysis in a suitable vessel, using preferably a carbon anode and an iron cathode and collecting the sodium in such manner that it will not be burned by the air. The proportions may be varied, and they have found that 15 parts of fluoride to 100 parts of NaCl form a very fluid and effective electrolyte.

Magnesium.—G. O. Seward and F. von Kuegelgen, 868,226, Oct. 15, 1907. Application filed Oct. 25, 1905.

The usual electrolyte for the production of magnesium is a fused mixture of magnesium chloride, $MgCl_2$, and an alkali chloride as KCl. The object of the patent is to add such a material which will so increase the specific gravity of the electrolyte that the liberated magnesium metal will float readily on the electrolyte and can be easily collected. For this purpose about 6 per cent of fluorspar is added to the molten mixture of $MgCl_2$ and KCl. This dissolves in the electrolyte. Barium fluoride may be substituted for fluorspar.

Electrolytic Production of Copper.—L. Jumau, 867,046. Sept. 24, 1907. Application filed Dec. 29, 1905.

Roasted copper ore is leached with a solution of ammonia mixed with ammonium sulphate or sulphite. The ammoniacal solution of copper thus obtained may be electrolyzed directly, or the ammonia wherewith the ore was treated may be recovered by evaporation and again used in a subsequent lixiviation of the ore. During the evaporation the copper is precipitated as oxide and may be again dissolved, for instance, in sulphuric acid. The cupric salts contained in the ammoniacal solution are preferably converted into cuprous salts by passing a current of sulphur dioxide (obtained from the roasting furnace) "into the ammoniacal solution, whereby cuprous sulphite or cuprosocupric sulphite or a double sulphite of copper and ammonia is formed." The deposition of copper from cuprous salts requires only one-half the ampere-hours necessary with cupric salt.

Recovery of Nickel.—C. H. Ehrenfeld and J. R. Grove, 868,769, Oct. 22, 1907. Application filed Jan. 27, 1906.

Crushed nickel ore is filled in a porous jar and used as anode, connection to the circuit being made by means of a carbon rod placed in the crushed ore. The jars are placed in the electrolytic tank containing a solution of 10 per cent of sulphuric acid and 10 per cent of acetate of ammonia in water. The nickel is deposited on cathodes outside of the porous jar.

Lead Oxide.—C. P. Townsend, 867,320, Oct. 1, 1907. Application filed April 24, 1905. Assigned to E. A. Sperry.

If a solution of sodium acetate or other alkali metal salt, which is capable of yielding a solvent for lead at the anode by electrolytic decomposition, be electrolyzed between electrodes of lead, a solution of acetate or other salt of lead is formed at the anode, while at the cathode the hydroxide of the alkali metal is produced in equivalent quantity. This alkali metal hydroxide reacts with the lead salt to form a white amorphous precipitate of lead hydroxide, the sodium acetate or equivalent salt employed as an electrolyte being simultaneously regenerated. The special feature of the present invention is that by suitably modifying the above conditions a characteristic crystalline product may be obtained, said product consisting substantially of lead oxide, PbO, instead of the hydrate obtained as above described. A preferred mode of carrying out the process is as follows: An electrolytic cell having an anode of lead and any suitable cathode is sub-divided by a diaphragm of parchment paper, the cathode compartment being advantageously of relatively small capacity. The anolyte consists initially of a solution of sodium acetate of convenient concentration; the initial catholyte may be sodium acetate, water, or preferably a solution of sodium hydroxide. In any case sodium hydroxide accumulates in the cathode compartment until a definite concentration is reached, which is dependent upon the

current strength, the temperature of the electrolyte and other factors, and which remains constant under uniform conditions. Under suitable current conditions brilliant yellow crystals of lead monoxide appear in the anolyte, these crystals or crystalline aggregates having usually the form of thin plates having opposite reëntrant angles. The following working conditions are convenient but may be widely varied: Anodes and cathodes of lead separated by a diaphragm; initial anolyte 10 per cent sodium acetate solution; initial catholyte 2.3 per cent sodium hydroxide solution; temperature of electrolyte 60° C.; current density 20 amps. per square foot electrode surface; potential difference 2.1 volts. When portions of the electrolyte carrying the yellow crystalline product in suspension are withdrawn and the crystals are separated by a filter press or by settling and are dried at about 100° C., the dry product is found to consist substantially of lead and oxygen and to correspond to the formula PbO. The product dried at comparatively low temperatures, as 100° C., possesses peculiar physical properties especially in that it darkens rapidly under the influence of light, and that the crystalline plates initially formed are subject to rapid disintegration. The product is further characterized by its tendency to hydrate in presence of water, acids or salts, a property which is highly advantageous as rendering it very quickly soluble even in dilute acids; in this respect it is sharply distinguished from ordinary litharge. If the crystalline product be heated to a temperature considerably above 100° C., and preferably to low redness, it is found to differ in several important respects from the product dried at 100° C., and to approach more nearly in properties the monoxide of lead as heretofore known.

Lead Pigment.—E. A. Sperry, 867,435, Oct. 1 1907. Application filed Aug. 30, 1906.

For the electrolytic production of a lead pigment a previous electrolytic treatment of the lead is stated to be highly advantageous, whereby the lead is used as anode and deposited on the cathode and the cathode product is employed for making the pigment. "For instance, white lead produced electrolytically absorbs as high as 20 mm. (drops) of oil per gram to bring it to a standard paste, whereas by using the cathode product of the first electrolysis as anode in the second, the particle may be rendered harder; it then works entirely different in spreading under the brush, and has other physical characteristics which are different, but probably the most distinguishing feature is that with this lead it is possible to bring oil absorption down to between 3 and 4 mm. per gram. It should be noted in this connection that the after treatments in the two instances are identical with the same electrolyte in the same cell and with the same current density." In the first electrolytic treatment the inventor uses lead tartrate or lead acetate. The cathode lead obtained thereby is then treated electrolytically to produce the desired pigment. For instance to make orange mineral the cathode lead from the first electrolysis is washed and used as anode in a second electrolytic cell with sodium acetate as electrolyte. A diaphragm is preferably used to separate the electrodes, the pigment being produced in the anolyte upon the introduction of carbonic acid gas suitably into such anolyte. The white lead thus obtained is of a very superior quality. This is washed free from the electrolyte, and that portion which is to be utilized as orange mineral is then dried and subjected to oxidizing process either in an anodic reaction in electrolytic process or in a furnace at high temperature.

Lithopone.—J. B. and A. Candau, 868,253, Oct. 15, 1907. Application filed April 3, 1905.

Natural barium sulphate is roasted with coal, giving barium sulphide according to the reaction:

$$BaSO_4 + 4C = BaS + 4CO$$

This sulphide is lixiviated according to the ordinary methods. A solution of sodium sulphate is then electrolyzed in a diaphragm cell with zinc anodes and inert cathodes, forming zinc sulphate in the anode compartment and caustic soda in the cathode compartment. The zinc sulphate is precipitated by the barium sulphate which was obtained before, and lithopone is obtained according to the equation

$$ZnSO_4 + BaS = ZnS.BaSO_4.$$

If sodium chloride is used instead of sodium sulphate, zinc chloride is produced in the anode compartment. Lithopone is then obtained from the following complex reaction:

$$BaS + ZnCl_2 = BaCl_2 + ZnS.$$
$$BaCl_2 + Na_2SO_4 = BaSO_4 + 2NaCl.$$

Bleaching of Cotton.—A. A. Vogelsang, 867,452, Oct. 1, 1907. Application filed Sept. 21, 1904.

The method relates to the bleaching of cotton yarn in bulk, that is, without the bundles having to be unpacked, and is also applicable to the bleaching of cops and pirns. The bundles are placed on end in a tank in which they are first treated successively with a caustic solution, with an electrolytic bleaching liquor, and finally with a solution of sulphuric acid. The invention if applicable to the bleaching of curtains and piece goods, and in the case of curtains a convenient way is to provide a system of rollers so arranged that the articles can be wound backwards and forwards and be caused at the same time to pass through the vats in order to be acted on by the various solutions. The solutions employed may be of the following strengths: "For treating, say, a thousand pounds of cotton yarn, the salt solution may be formed by dissolving 400 kilogs. of salt in 10 cubic meters of water; the sulphuric acid solution by adding 20 pounds of commercial acid (at 66° Baume) to 600 liters, or, say, 2.3 cubic meters of water; while the caustic soda solution consists of 20 to 30 pounds of NaHO dissolved in about 2.5 cubic meters of water, and it is heated to about 50° before it is used."

Electrode.—J. W. Stubbs, 867,310, Oct. 1, 1907. Application filed April 9, 1907.

Carbon blocks form an active surface of the anode, but connection to the external circuit is through metallic rods. Exposed parts of the metallic surfaces are protected by means of a mass composed of a mixture of powdered carbon, resin and tetrachloride of carbon. One possible construction is shown in Fig. 2, where 1 is a metal conductor, covered for the greater part with Portland cement *b*, *c* is a mixture of graphite, resin and tetrachloride of carbon, molded round the end of the conductor, the outer surface of the mass being formed to fit into an opening *f* in the usual carbon block *g*. The end of the conductor is thus efficiently protected from chlorine or other corrosive agents in the electrolyte, and at the same time the electrical resistance of the junction is reduced, while when the block *g* is worn it can readily be removed and a new one put on; *h* is cement for protecting the outer end of the conductor when the opening *f* is made continuously through the block *g*.

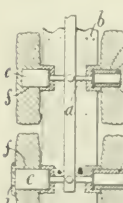


FIG. 2.—ELECTRODE.

Electroplating Apparatus.—I. Pattoff, 867,955, Sept. 24, 1907. Application filed May 3, 1906.

The devices described in the patent are essentially those which were described and illustrated in our August issue, page 331. The first claim reads as follows: "In an electroplating apparatus, the combination with a galvanizing tank and a washing tank, of a single means for moving material through the galvanizing tank to be galvanized and mechanically discharging the material from the washing tank from the galvanizing tank."

Metallic Deposits.—I. Trotsky, 868,729, Oct. 22, 1907. Application filed June 3, 1906.

In order to increase the adhesion and the lustre of electr-

lytic metallic deposits, an addition of sugar and a ferment to the electrolyte is recommended. For instance, for depositing zinc the electrolysis is made up by making a mixture of 25 kg. of crystallized sulphate of zinc, 15 kg. of aluminium sulphate, 1 kg. of calcium carbonate, 4 kg. of maltose or dextrose and 0.5 kg. of beer barm.

Batteries.

Storage Battery Plates.—H. Leitner, 867,517, Oct. 1, 1907. Application filed Aug. 25, 1904.

The first claim relates to "the process of preparing electrodes for secondary batteries, which consists in immersing the plate in a weak electrolyte, comprising a sulphate solution containing not more than 3½ per cent of the sulphate, to which is added not more than 3½ parts per 1,000 of a chloride, and subjecting the plate as an anode to an electric current of as high density as possible, without raising the temperature of the electrolyte, about 85° F., artificially cooling the electrolyte to permit the use of a higher current density than could otherwise be employed, then washing the plate to cleanse it and consolidate the oxidized layer, then treating the plate as a cathode in an innocuous electrolyte, treating the plate with water and then exposing it to the action of warm air."

Storage Battery Plate.—J. Marx, 867,391, Oct. 1, 1907. Application filed Jan. 30, 1907.

The first claim refers to "a storage battery plate, comprising a frame embodying spaced side bars, bottom and top bars and an intermediate bar, horizontally extending shelves and vertically extending spaced ribs on both sides of said shelves, and units adapted to be held between said shelves and ribs."

Discharges Through Gases.

Sulphuric Acid.—I. Kitsee, 869,094, Oct. 22, 1907. Application filed July 21, 1906.

Sulphuric acid gases are oxidized to sulphuric acid without the aid of a contact mass by simply conveying the gases through ozonized air. The air is ozonized in the usual way by means of electric discharges. If the gases are heated with the addition of some superheated steam the formation of sulphuric acid takes place more rapidly than if the gases are dry.

RECENT METALLURGICAL PATENTS

Iron and Steel.

Iron Reduction with Gaseous Fuel.—The special conditions of California with its scarcity of solid fuel and its abundance of oil are indicated in a process of smelting iron ore patented by Henry Arden, of Los Angeles (869,043 and 869,125, Oct. 22, 1907). A hematite or other iron ore, usually mixed with a suitable flux and with a relatively small proportion of fixed carbon, is charged into the furnace similar in design to an ordinary blast furnace but provided with two sets of tuyeres at different levels, the lower set being located as usual at the level of the crucible and the upper set at approximately one-third the height of the furnace above the crucible. A relatively small proportion of fixed carbon is incorporated with the charge the amount being sufficient to provide the metal with the 3 or 4 per cent of carbon necessary for its conversion into pig, together with such excess as may be required to effect the reduction of any oxide not reduced by the gaseous fuel. Through the upper tuyeres preheated carbon monoxide is introduced, so as to preheat the ore charge. With the heated carbon monoxide a hydrocarbon, such as a heavy petroleum, previously evaporated and commingled with the gas, is introduced in order to facilitate the absorption of the carbon by the iron. Through the lower tuyeres located at the reducing zone carbon monoxide is introduced preheated to such a high temperature as to effect reduction of the iron oxide. The high temperature is attained by passing the carbon monoxide through an electric furnace adjacent to the smelting furnace, the electric furnace being of the resistance type and provided with heated surface of carbon. In this furnace the carbon monoxide to be introduced through the lower tuyeres is superheated. The gas introduced into the upper tuyeres should be substantially free from carbon dioxide; for this purpose the gas is passed over ignited carbon before being supplied to the upper tuyeres. The carbon monoxide is produced by the production of petroleum or other hydrocarbon in a suitable furnace, the proportion of air being regulated so as to yield carbon monoxide only. The inventor prefers to use an electric resistance furnace for this purpose. In certain cases it is advisable to prevent the carbon from being oxidized during its passage from the upper portion of the furnace to the reducing zone, and this is accomplished by coating the carbon particles with sodium silicate.

Special Steel.—J. Churchward (868,327, Oct. 15, 1907) patents a steel composed of 95.10 per cent of steel (containing 0.6 per cent carbon), 3 per cent nickel, 1.50 chromium, 0.15 vanadium and 0.25 manganese. The percentages may be varied within the following limits

Steel (.20% to 1.25% carbon) from.....	98.30	parts to	91.50 parts.
Nickel from.....	1.00	"	3.50 "
Chromium from.....	.50	"	2.50 "
Manganese from.....	.15	"	1.00 "
Vanadium from.....	.05	"	1.50 "
	100.00	"	100.00 "

"It is believed that the alloying elements named react in a chemical manner on each other, producing molecular changes of such a nature that the nickel, chromium and manganese harden and toughen, and the nickel and vanadium remove or prevent brittleness without softening the alloy."

Calcium for Steel Refining.—J. Misko (868,610, Oct. 15) proposes to refine steel by means of calcium in form of calcium carbide. On account of the high melting point of the latter he uses an alloy of iron and calcium carbide which he calls ferro-calcium-carbide, containing preferably 90 per cent of iron, 6 per cent of calcium and 4 per cent of carbon. To purify iron or steel the alloy is added to the molten metal, The resulting reaction is almost instantaneous. The calcium combines with the sulphur, phosphorus and the gases. It is not necessary in all cases to melt the ferro-calcium-carbide, since it can be thrown into an open-hearth furnace containing molten steel or into a bessemer converter, and also into a cupola furnace where cast iron is being melted.

Lead.

Joining of Cables, Pipes, Etc.—To join pipes or lead-covered cables, S. L. Smith and T. Harden (868,498, Oct. 15, 1907) patent a flux made as follows: 3 ounces of stearin, 4 ounces of vaseline and 1 tablespoonful of methylated spirit are melted together, and the composition is spread as thinly and evenly as possible upon a sheet of tinfoil weighing 5 ounces per square foot, and another sheet of tinfoil is then pressed down upon the first, making a sandwich which may be rolled, cut into strips, etc. If this sandwich is placed in contact with the surface of a suitable metal and molten lead is poured thereon the lead as it cools will alloy with and adhere to the metal surface. For instance, to join two lead pipes the ends are scraped and put together and the flux is wrapped around the scraped ends and the mold is affixed to the parts to be joined and molten lead poured in.

Gold and Silver.

Cyanide Process.—B. Hall (868,551, Oct. 15, 1907) mixes the crushed ores or concentrates with a cyanide solution to reduce the mass to a loose moist condition. For this purpose the dry material is moistened with from 10 to 20 per cent of cyanide solution, this depending upon the fineness of the material. The mass is then loosened up until it is in such a porous condition that air will circulate through the mass. It is well known that the oxygen of the air is necessary for the reaction. The reaction requires from one to ten days, after which simple leaching with water is required.

Miscellaneous.

Ore-Testing Crucible.—J. E. Hunsinger (868,270, Oct. 15, 1907) patents an ore-testing tablet or crucible for use of the prospector on the spot. The crucible is of such composition as to produce a reducing heat when ignited, and having such fluxes or reagents as the quality of the ore being treated may demand. The tablet is formed of 15 parts of powdered hardwood charcoal, 8 parts of chlorate of potash and 6 parts of sodium carbonate. This composition is made plastic by paste made of flour and water, and the mass is shaped into round tablets with a plurality of small cells or into crucibles with a large central receptacle. To test the ore, "crush a small amount of ore and grind very fine; then sift through a fine mesh cloth or sieve; place the pulp on top of a tablet or crucible and carefully fill all of the cells and strike off from the top all the remaining pulp; then light the tablet with a match, and when burned and thoroughly cooled place the slag in a suitable mortar and triturate until all of the slag has been washed off. The slag is dissolved at once when water is poured thereon, and any remaining lumps can easily be reduced with the pestle so that every particle of metal may be saved if the operator is careful in panning." For refractory ores where more heat is required two tablets are used, one placed directly on top of the other. A crucible form is shown which is said to be especially suitable for retorting small amounts of amalgam.

Free Engineering Library.

On and after Wednesday, Nov. 6, 1907, the reference libraries of the American Institute of Electrical Engineers, the American Society of Mechanical Engineers and the American Institute of Mining Engineers, 29 West Thirty-ninth Street, New York, will be open evenings until 9 o'clock on all week days except public holidays. These libraries, constituting practically one library of engineering, situated near the New York Library, in the new headquarters of the United Engineering Societies, are available to members of the above societies, engineers, and the public generally, subject to proper regulations. Strangers are requested to bring letters of introduction from members or to secure cards from the secretaries of the respective societies.

Acid-Proof Brick and Tile.

Acid-proof brick and tile is used extensively for floorings in plating rooms, copper refineries, caustic soda vats, sulphate pulp digesters and in general in all places where perfect non-absorbent, strictly acid-proof floorings or linings are required, and is rapidly claiming the attention of manufacturers in industrial spheres where it was not used before.

The New York Brick & Paving Co., of Syracuse, N. Y., have in the market to-day, and have had for the past fifteen years, a brick which is daily forging ahead in this particular line. These brick are made of alluvial clays, or rather clays of an alluvial deposit, and are a mixture of clays containing very little lime or iron; if any is found in the same the extreme heat in the process of vitrifaction completely destroys them. On this fact is based the great superiority of this brick over ordinary vitrified brick.

These acid-proof brick have been tested by a great many of the best chemists in the United States, and have never failed to prove their excellent quality as acid resisting. No acid has yet been found to affect them, although strongly concentrated solutions have been used on them. The brick are perfectly vitrified, and to accomplish this they are subjected to almost white heat in the process of vitrifaction. Very few clays except this particular one could withstand such a process of vitrifaction.

For the past fifteen years the New York Brick & Paving Co. has been supplying many brass foundries, copper works, as well as sulphite pulp manufacturers with these brick for their various uses, while during the past five years the manufacturers in various metal industries, where hot material is apt to be found on floors, vats, etc., have finally adopted these brick as floorings as being the most durable since they will outwear any three floors of any other kind of material.

The brick are 2 and 2½ inches thick and 7½ inches long. A double brick or tile is also manufactured by the company of the size 7½ inches x 7½ inches x 2 inches, which is recommended where it is essential to have as few seams as possible. The small size brick answers for any ordinary flooring. The manufacturer, the New York Brick & Paving Co., 204 S. A. & K. Building, Syracuse, N. Y., request correspondence with interested parties and furnish samples upon application.

Concentrating Magnetite Iron Ore at Lyon Mountain, N. Y.

The Delaware & Hudson Co., of Albany, operates extensively in the magnetite mines of Lyon Mountain, N. Y., where for twenty years the crude ore with an average yield of 32 per cent has been mined. In the old mill wet concentration was used, but the new mill, which has only been completed since May, 1906, is arranged for using dry magnetic methods, and the ore is brought to the separator plant without sorting.

The crushing capacity of the new mill is from 1,000 to 1,200 tons of crude ore in 24 hours; 375 hp. is required to run the mill, and ore is crushed to ¼ inch to obtain the best results in separation. Nearly all of the machinery used to equip the new mill was purchased from Allis-Chalmers Co., of Milwaukee.

The mill is divided into three sections, each of which can be separately operated. The crude ore, after weighing, is dumped into a bin of 700 tons capacity, from which it passes over a grizzley of manganese steel bars to a 24-inch x 30-inch Blake crusher and is reduced to about 5 inches. Then the ore passes over a second grizzley to a No. 6 "K" Gates gyratory ore crusher, which reduced it to 2½-inch product. The ore is then delivered to a belt conveyor, which also receives the fine material from the grizzleys and carries the product to a set of 40-inch x 30-inch Allis-Chalmers crushing rolls. These rolls crush the ore to 1 inch in size, and from them it is elevated to the top of a vertical dryer. After drying, the product is delivered to the bucket elevator and thence to a second storage bin.

Sizing screens are fed from these bins by means of feed rolls, the over size and the ¼-inch material being delivered to 40-inch x 15-inch crushing rolls of the same type as the coarse rolls. Then the material is passed over revolving screens with ¼ inch apertures. The over size is returned to the rolls, while the ¼-inch material is elevated to bins over the separator section.

The capacity of each separator is 15 to 20 tons of crude ore. The middlings and tailings from the four primary separations are recrushed on four sets of rolls and again treated on a second set of separators.

The final product, concentrates and tailings is carried out of the mill on two belt conveyors to the loading pockets. The concentrate pocket has a capacity of about 600 tons. The tailings pass over revolving screens with ¼ inch apertures, which deliver each product into a bin of 300 tons capacity.

The fine tailings have found good use as commutative sand being dry, sharp and clean. The coarse material makes excellent railroad ballast, and is also used for concrete sand.

Excellent results have been obtained here in the separation of magnetite from tailings. Five years ago the tailings from the old mill used to carry 12 to 15 per cent iron. By recrushing and retreating them in the magnetic separator the iron residue has been brought down to 4 per cent in the new mill.

Modern Copper Converters, Hydraulically Operated.

By G. B. Shipley.

A very interesting and modern converter installation is now being made by the Mammoth Copper Company at Kennet, Cal., under the supervision of C. F. Moore, chief engineer. All of the machinery has been designed to meet the most exacting conditions.

The evolution of machinery for converting copper has consisted of a progressive series of improvements, due principally to the many practical experiments made by the various operators at different plants throughout the world, and particularly in the United States. By combining the latest ideas that have yielded the best results, and eliminating defects, it has been possible to build a converter which has many advantages over those used a few years ago.

The converter equipment for the Mammoth Copper Company consists of two hydraulically operated stands and eight shells, 96 inches in diameter by 150 inches long.

Shells.—Referring to the illustration, it will be noted that the shell at the top half has a peculiar shape, which is not found in other converters. The bottom half is 96 inches in diameter, and from the center up to the joint, both sides of the shell are formed in a tangent to a width at the top of about 7 feet. The object of this is to do away with the unnecessary curvature above the center line to permit of a more secure lining being formed.

The parting joint between the bottom half and the top half of the shell is considerably higher than in other designs, the idea being to keep this just as high as possible and away from the extreme action of the molten copper; for it is a fact that in practically all of the barrel converters, with the exception of those at the plants of the Anaconda Copper Mining Company and the Orford Copper Company, this joint is only carried a short distance above the center line; and, since there is here no chance to ram the lining, it is only possible to form the joint with an adobe mixture. The result is that the joint is eaten away very rapidly by the molten matte. In the new type of hydraulically turned converter, built by Allis-Chalmers Company, this vital defect has been overcome by raising the joint between the bottom and top shell.

The bottom section of the shell is made of flange steel plate, which is reinforced longitudinally by four heavy T-rails and rigidly secured at both ends to a solid cast-steel head provided with a riding ring cast integral with and completely encircling the head.

Each head is spherical in shape and reinforced with eight heavy ribs to reduce expansion and contraction resulting from the intense heat. In a great many converters, designed without the ribs, much trouble has been caused and a great deal of expense incurred in fitting relined shells into stands which have the air connections bolted to the heads.

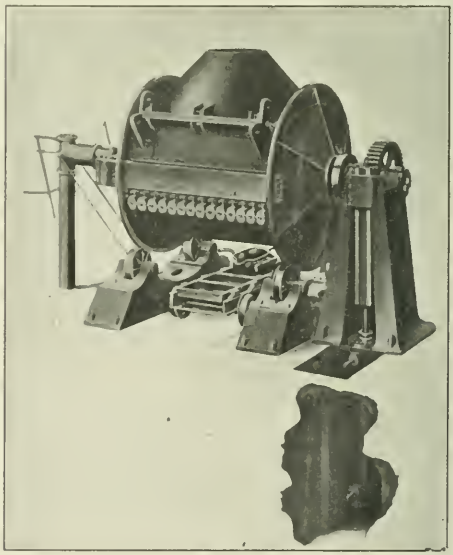
For lifting the shells there is riveted at the joint on the lower half a solid cast-steel re-enforcing plate, which has cast integral with it one heavy lug on each plate, making four lifting lugs in all. These re-enforcing plates or angles are also arranged for bolting on the top half by three extra heavy bolts on each side.

The pouring top is made of cast steel and is parted on the longitudinal center line, thus making this part in two interchangeable sections, which is an important feature when repairs are considered. In some casees a great many operators are in favor of fitting the top with a short cast-iron pouring nose, which can be removed and thrown away when eaten up by the molten metal, and another substituted, whereas there are others who insist that the separate pouring nose is very objectionable, inasmuch as the additional flanges furnish places for accretions to form. With the top as shown in the illustration, it is only necessary to rivet a steel plate at the burnt-out portion. The shape of the top of this converter, as well as the bottom, is practically the same as that of the converters in use at Anaconda, Mont. It is a peculiar shape which gives longer life to the lining.

The wind box is rectangular in shape and consists of a plain casting which lies close to the shell and underneath the riding ring, thus permitting the shells to make a complete revolution and thereby do away with the stop which it has been customary to place on a great many riding rings in order to protect the wind box and prevent the shell from turning too far. With the old stop arrangements it was necessary to be very careful in turning; otherwise an operator might throw the shells off the stands, thus causing a serious accident.

Another feature of the self-contained wind box is that it does away with the long flange and cover which has always been used where the air valves or tuyeres were fitted on the inside of the wind box. It is well known that there is always a great loss of air through the joint in the long cover ordinarily used, because the expansion and contraction and the hard service to which converters are subjected in a very short time ruins the joint.

Individual Tuyeres.—On each of the Mammoth Copper Company's converters there are fitted sixteen Redpath individual tuyeres, having Dyblie ball valves, and secured to the



CONVERTER.

wind box by swing bolts. The discharge end of each valve, which is at right angles to the inlet, projects several inches inside the shell and through a cast-steel stuffing box secured to the shell. This stuffing box is bored out to suit the projection on the tuyere, and is arranged for holding asbestos packing, to prevent air leaks, while the projection inside the shell is sufficient so that a lining of brick can be fitted securely around it.

Each tuyere is arranged so that the ball valve and its seat are self-contained, and the valve can be quickly taken out and replaced by another. The pipe distance-piece is also independent and easily accessible. Therefore, it will be seen that with this individual arrangement of tuyeres, it is only necessary to disconnect two swing bolts and pull out the

tuyere; it is not necessary, when replacing a single defective pipe distance-piece, to disconnect a long and heavy cover and have the great difficulty of trying to make a joint on a long and warped casting.

The opinion of many will probably be that accretions will form between the wind box,, tuyeres, and shell, to such an extent that it will not be possible to get at the swing bolts which fasten the tuyeres to the wind box; but this is not the case, because to obviate this there is an angle on top of the wind box, which runs for the full length and is riveted to the shell.

It has been demonstrated that the ball valve is more satisfactory than the roller or flap valve, because the spherical shape of the ball adjusts itself to the valve seat, leaving no chance for grooves to form as a result of the hard usage and constant pounding of the tuyere punching bar

Air Connection.—On the air end of each shell, the cast-steel head is arranged to receive the end of the wind box, which is fitted with a ball-joint concave flange, and receives the stationary air nipple of the patented blast connection.

This joint is especially adapted to converters and air joints where it is not possible to bring flanges in line, by reason of the difference in centers of shells, which are bound to become distorted and lose part of their shape after hard usage. This connection consists of a cast-iron T, having the horizontal cylinder fitted with a ball-joint and piston. When the shell is moved into position the lever is pushed forward, and this moves the nipple into the concave flange on the head. The air is then turned on and the pressure upon the piston holds the joint rigidly in place.

This joint is superior to the old method of matching flanges, and has proved to be a great labor-saving device around converter plants.

Hydraulically Operated Stands.—For turning the shell each stand built for the Mammoth Copper Company is provided with a pressure cylinder 18 inches in diameter, having a stroke of 7 feet, which is equivalent to turning shells 180 degrees. The piston is fitted with four special metallic packing rings, which are designed to obviate leakage, wear, and the expensive delays due to repairing soft packing.

The upper end of the cylinder is secured to a flange on the bottom of an A frame and at each end are bolted independent heads. The upper head is fitted with a brass neck bushing and a well-proportioned stuffing box. It will therefore be apparent that with this arrangement it is possible to take the piston and rod out through the top, which is a very desirable feature.

The driving stand is a solid cast-iron box section "A" frame with liberal bearing surface at base, which is arranged for securing to foundation with four 1¼-inch bolts

The upper portion of this driving frame is designed to receive the turning mechanism, which consists of a cast-steel rack and cast-steel shrouded spur-gear. The rack is connected at the lower end of the piston, and opposite to center line of shaft at the upper end a guide is arranged, with a well proportioned sliding surface. Thus it will be seen that the turning motion is transferred from the piston and rack to the gear.

The gear is keyed to a hollow steel shaft which has fitted to its driving end a universal coupling, arranged so that the shells will rest true on the rollers, and that at the same time the drive will adjust itself to suit the alignment, thus avoiding any undue strains on the driving shaft.

On the head of the shell is a groove, which matches a tongue on the universal drive; the main gear is turned around until the tongue is vertical, when the shell is placed and there is clearance enough on each side of the tongue for keys, which are tapped into place by a light hammer, thus holding the shell rigid to the universal connection.

In some converters this groove on the shell has only sufficient clearance to allow the shell to drop over the tongue, and no provision is made for using the keys in which case there is danger of a back lash, due to the clearance and the fact that the piston will have a chance to accelerate before it picks up the shell, the result being a severe shock which is detrimental to the gears.

Housing.—There is a sheet-steel housing for each frame, which covers the driving gear to prevent dirt from getting into the operating parts.

Pouring Spoon.—A very important detail in connection with the pouring of a converter is to obviate spatter or spilling of the copper upon the floor, and to prevent this there is furnished, when requested, a Bennetts' pouring spoon, hung on a steel arm on one side of the roller stand, as may be seen from the cut, with the arm so arranged that the spoon can be adjusted to suit the pour of copper from the shell and the position of the molds which rest on the truck directly underneath.

Another important detail, which is not shown in the illustration, is a mold car mover, attached to a slide on the inside of the roller stand next to the frame. This mover is operated by an air or hydraulic cylinder, which in turn transmits its power through a piston rod to a guide with an arm that can be dropped into place on a mold car, thus pushing the car along into the proper position to suit the molds.

The following data in relation to these converters will be of interest:

	Tons.
Weight of shell	19
Weight of lining	44
Total	63

Cubic feet of concrete in foundation 1,200.
Capacity of charge 40 per cent. matte.
First charge (new lining) 8.25 tons.
Average charge 10.00 tons.
Maximum charge 14 to 16 tons.
Air-blast pressure 12 to 15 pounds.

Assuming six charges per stand per 24 hours, and twenty-six working days per month, the capacity of each 96-inch by 150-inch converter will be about 1,250,000 pounds of copper per month. Of course this will all depend upon the matte and the conditions under which the converter is operating. In some cases the capacity could be increased 30 per cent. where converting is being done under ideal conditions, whereas in badly arranged plants the above capacity would be high.

C. H. Repath, engineer of the Anaconda Copper Mining Company; F. E. Marcy, of Salt Lake; J. A. Dyblio, and B. H Bennetts, all deserve special mention for the many features which are incorporated in the hydraulically-operated copper converter described.

Agitating Sulphur Burner.

One of the first uses to which gas analysis was put in the chemical industries was in the manufacture of sulphur dioxide by burning sulphur. It was early recognized that if the supply of air to the sulphur burners was not exactly regulated the operation did not proceed to the best advantage, and for this reason it became general practice to analyze the gases coming from the burners and regulate the air supply to the burners accordingly

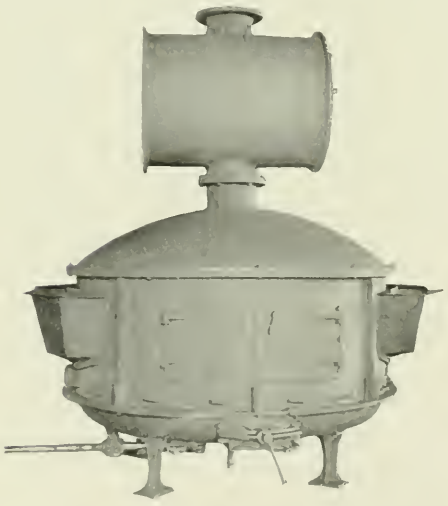
Although this method of regulating the air supply represented a great advance over the old-style sulphur burners, to which air was admitted from the end in unrestricted quantity and ungoverned proportion to the sulphur vapor, yet a perfectly uniform gas could not be obtained, since the conditions in the apparatus fluctuated during operation, and especially since they were not perfectly uniform in all parts of the apparatus.

The fundamental feature of a new agitating sulphur burner

invented by Mr. J. C. Wise and built by the Raquette Foundry & Supply Co., of Massena, N. Y., as shown in the accompanying illustration, is such a construction that those obnoxious fluctuations are avoided and perfect uniformity of conditions within the combustion chamber of the apparatus is assured.

In the old-style burners the feeding of the oven was the cause of fluctuating conditions. The cold charge smothered for an appreciable period the surface flames upon which it was thrown, thereby lowering the temperature and reducing the capacity. Being fed through the door, the operation allowed an excess of oxygen to rush through the system during the feeding. These troubles are done away with in the Wise sulphur burner by means of the use of automatic hoppers, in which the sulphur is melted by radiated heat and flows in a continuous stream into the bowl of the oven, being at the same temperatures as the contents so that any chilling effect is avoided. The sulphur supply may be regulated to equal the consumption, so that the quantity of sulphur in the bowl remains constant.

With respect to the possibility of maintaining perfectly uniform conditions within the apparatus itself, great emphasis is laid upon the fact that the general form of the pot is circular, and that the draft slots are, therefore, arranged in the form of



SULPHUR BURNER.

a circle and are equidistant from the center of the pot. By this arrangement the several distinct volumes of air passing inward radially through the different slots toward the center of the burner, must travel equal distances, and are, therefore, exposed to like conditions. The tendency is to produce uniformity in the conditions existing throughout the pot and to promote the uniform combustion of the sulphur vapor.

Actual trials have shown that the circular form of the pot increased the general efficiency of the apparatus to an astonishing degree. This is undoubtedly due to the fact that because of the several drafts being produced in different directions but converging towards the center of the pot, a uniform mixture of air and sulphur vapor is produced. Moreover, the combustion chamber is provided with a horizontal baffle-plate or partition with four equal slots at each end. The gas passing from the chamber is therefore split up into ten streams which unite in the upper compartment. This again promotes thorough admixture of air and sulphur vapor.

In some instances it is desirable to admit some air through the dampers or draft slots, located at the ends of different slots in the baffle-plate. The shutters at the ends of the combustion box may be opened to any desired extent, admitting a corresponding amount of air. This auxiliary admission of air is desirable when, for any reason, difficulty is encountered in causing thorough combustion within the oven, and, consequently, there is a tendency for unburned sulphur vapors to pass off in elementary form. Air, when admitted through the ends of the box, as above described, will cause any unburned sulphur vapors to burn and form SO_2, provided the aeriform portions just mentioned have sufficient heat. It should be borne in mind that it may sometimes happen especially in a rapidly working apparatus, that some portion of sulphur vapor is not brought into contact with a proportionate quantity of air, and while possessing sufficient heat to support combustion, is prevented from being consumed upon this account. In such an instance, the auxiliary air outlets are also useful. The dampers and baffle-plates are essential to thorough combustion.

The first machine of this type was installed in July, 1905, in the Deferiet mill of the St. Regis Paper Co., and has given continually perfect satisfaction. When tested recently no material wear or deterioration could be detected.

During a week's test this machine burned 14,000 pounds of American sulphur in 24 hours, producing a gas testing 18 to 19 per cent SO_2. It occupies only 38½ square feet of floor space, is 10 feet 6 inches high, and weighs approximately 10,000 pounds.

The experience of the Fort Edward mill of the International Paper Co., where two machines of this type were installed in August, 1906, is also interesting. Formerly fifteen flat burners of a total burning area of 460 square feet were employed, in connection with four Partington systems of three tanks each. Each system was equipped with an 18 x 20 duplex vacuum pump. Full capacity was seldom obtained. After the installation of the two new Wise machines the use of the old burners was discontinued and two entire acid systems with the exhausters were cut off. The capacity was greatly increased and an immense saving of sulphur and lime per ton of sulphate pulp was shown. A gas of 18 per cent SO_2 is commonly obtained, and the two machines make about 80 tons sulphite pulp daily.

The very high efficiency obtained is evident from the fact that if the operation was ideal, the sulphur being burnt with atmospheric air of standard composition according to theoretical proportions, the proportion of SO_2 in the gas would be about 21 per cent.

Low Temperature Measurements.

Compared with the enormous progress which has been made in the last years in high-temperature measurements by multifarious methods, comparatively little had been done with respect to low-temperature measurements. For this reason some details of a low-temperature "pyrometer," recently built by the Wilson-Maeulen Co., of New York City, will be found of great interest.

We should, of course, not speak of a "pyrometer" since the instrument is intended to be used in the cold and not in the heat—although the fundamental principle is the same, that of the thermo-couple. There is further some liability of mixing up the usual terms. We speak of the "cold junction" of a thermo-couple and mean the one which is held on a constant temperature, for instance, in melting ice. For a low-temperature instrument, however, this junction really is the warmer junction.

That thermoelectric couples with platinum and its alloys give reliable indications of temperatures above the freezing point of water is of course generally recognized. In endeavoring to extend the sphere of usefulness of the thermo-couple far below

the zero point, the Wilson-Maculen Co. found that for this special purpose it was preferable not to use platinum, but wires of base metals.

The object was to design an instrument which would give reliable and quick indications of temperature down to about 300° F. In solving the problem the Wilson-Maculen Co. arranges several couples of base metals in series so that the e. m. f. of the compound thermo-couple is a multiple of the e. m. f. of the single couple.

High internal-resistance galvanometers, as generally found in laboratories and workshops may be used with such compound couples so that it is possible to cover practically the whole temperature scale from the coldest to the highest temperatures obtainable in practice. Practically all galvanometers for thermo-electric work are graduated in millivolts as well as in degrees which correspond with the couples sold with them, and the Wilson-Maculen Co. supply the base-metal thermo-couples with a temperature chart showing the relation between the millivolt indications on the galvanometer and the actual difference in temperature. It is, therefore, not difficult to use one of these very inexpensive couples, which are of high accuracy for moderate temperature work.

From a test made of six compound thermo-couples at the Bureau of Standards in Washington, the following points are interesting. The couples were tested with immersion of the variable-temperature junction to a depth of about 8 inches in steam, solid carbonic acid and alcohol, and liquid air. The six couples were found to be nearly identical in their behavior. In the steam point the greatest difference in the mean was equivalent to 1.1° F. At the carbonic acid point it was equivalent to 0.3° F., at the liquid air point the agreement was still closer. The observed values were, therefore, averaged, and the couples treated as identical.

An equation of the form $E = at - bt^2 + ct^3$ was computed from these averaged observations and a curve was drawn representing the equation. From this curve the value of the temperature for every millivolt may be found. The results expressed on the Fahrenheit and Centigrade scale are given in the following table, which is applicable when the constant temperature junction is at 32° F. or 0° C.

Millivolts	10.00	6.00	2.00	- 2.00	−8.00	−14.00	−20.00	−26.00
Degrees F.	122°	88	51	13	−48	−117	−196	−298
Degrees C.	50°	31.1	10.6	−10.6	−44.4	−82.8	−126.7	−183.3

The accuracy of the values is within 2° F. at the lowest temperatures and somewhat better at the higher temperatures. It is interesting to note that the temperature of −183.3° C. is not more than 90 Centigrade degrees above the theoretical "absolute zero" point of temperature.

The resistance of the couples were measured at room temperature and found to be nearly identical. The values, reduced to the ice point by means of the known temperature coefficients and measurements of the diameters of the copper and constantan wires, were all between 3.58 ohms and 3.60 ohms. The resistance increases with rising temperature, in the vicinity of room temperatures, by about 0.004 ohm per degree Fahrenheit.

With a voltmeter resistance of 135 ohms and a total resistance of 140 ohms, the differences between the resistances of the couples and their variations of resistance, unless very deeply immersed, will be entirely negligible.

Nickel, Cobalt, Tungsten, Vanadium, Molybdenum, Titanium, Uranium and Tantalum.—A recent publication of the United States Geological Survey, by Frank L. Hess, gives statistical data on the production of the minerals in 1906, with interesting notes on their applications in connection with incandescent lamps and special steels. Almost no nickel is produced in this country, and, as usual, much more nickel was imported during 1906 than was consumed, the greater part of the matte produced in Ontario being shipped to this country for refining.

A New Laboratory Electric Furnace and Pyrometer Outfit.

A preliminary model of the new patented quartz-lined electric furnace, designed by Prof. Wm. H. Bristol, was described in the Electrochemical and Metallurgical Industry, February, 1907, and a few of the possible applications of it for practical work were mentioned. This furnace has now been developed into a suitable form for use with the Wm. H. Bristol recording electric pyrometer (described in the Electrochemical and Metallurgical Industry, November, 1906), in such a way that the temperature inside the furnace may not only be controlled, but also automatically recorded on a chart. A special laboratory unit consisting of this electric furnace and recording pyrometer with attachments, designed for determining the recalescent points of steel and for hardening small

Fig. 1.—Quartz-lined Electric Furnace for Hardening Small Tools.

parts, is shown in Fig. 2, with the various parts all mounted on the same standard in such compact form that the complete unit may even be conveniently used on an office desk, the electric current being supplied from an ordinary lighting circuit.

The electric furnace itself is of very simple construction, its special patented feature being the lining of fused quartz, which makes it possible to turn on the full current suddenly and thus to heat up the furnace quickly without danger of cracking its interior. Even when the furnace is heated to a bright red, a cold piece of steel may be introduced without injury to the quartz lining, which at the same time serves as a perfect insulator between the metal and the heating coils. A rheostat may be used to regulate the temperature, but for some applications this may be dispensed with, as, for instance,

in the use of the furnace as a soldering-iron heater with direct lamp-plug connection. In that case, the winding of the heating coil is so arranged that the maximum temperature of the furnace will be correct for continuous service and not so high as to oxidize the soldering iron. For many other applications as for tools and for laboratory work, both a rheostat and a pyrometer are used with the furnace to great advantage.

Fig. 2 shows the new laboratory unit especially designed for determining the recalescent points of various kinds of steel. The electric furnace is here shown in circuit with a rheostat so that after the full current has been turned on, bringing the furnace up to a bright red heat on the inside almost immediately, the rheostat may be adjusted so as to maintain the desired temperature.

This illustration also shows the complete recording pyrometer mounted on the same standard and consisting of a platinum platinum-rhodium thermocouple and a recorder. The couple of the pyrometer fits into the furnace and has its "cold junction" (or point where the flexible leads begin) inserted into a beaker of ice water. This thermocouple measures the temperature inside the furnace and actuates the recording instrument of the electric pyrometer, the recording arm of which makes a continuous record automatically on its circular chart.

The recording pyrometer is equipped with the patented semi-transparent smoked chart and a special vibrating device which brings the sensitive surface of this chart in contact every half second with the recording arm of a special Weston electrical movement. As friction between the recording arm and the chart is eliminated, a perfectly accurate record is obtained directly without the use of relays or other complicated devices. A chart of special graduations covering a range of 2,000° F., as shown in Fig. 3, is furnished with the outfit. In order that very quick variations of temperature may be recorded, this chart is arranged to revolve once in 60 minutes.

The special design of this laboratory unit makes it very convenient for measuring the recalescent points of steel, or, in other words, the temperature at which a molecular transformation occurs, below which the steel cannot be hardened. To obtain a record of the recalescent points of a lot of steel,

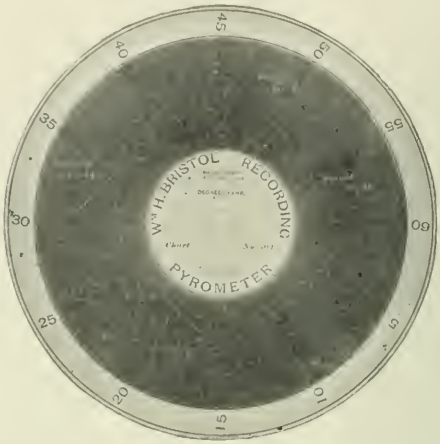


FIG. 3.—RECORDING PYROMETER CHART, SHOWING RECALESCENT POINTS OF STEEL.

a small sample is selected of cylindrical form about 7/16 inches diameter and about 1¼ inches long. A hole of ⅛ inch diameter and ¾ inch deep is drilled into the end of the sample. After the electric furnace has been heated up by turning on the current, this piece of steel is inserted into the top of the furnace and the tip of the thermocouple is introduced into the hole of the sample. As the steel is gradually heated up by the furnace, the rising temperature inside it will be recorded on the chart. After the temperature has been raised as far as desired, the piece of steel may be withdrawn from the furnace without disturbing the couple, and, as the steel cools, its falling temperature will also be recorded on the chart.

The records of these rising and falling temperatures will be shown as curves on the charts on which the recalescent points will be easily discovered. Fig. 3 shows a chart with four of these records made with four different samples. Sample No. 2 was wrought iron, and its heating and cooling curves show no points where the rise or fall of temperature was retarded. Sample No. 7 was 1.25 per cent carbon steel, and was treated in exactly the same manner as sample No. 2. The record for No. 7 shows two points of retardation, one for heating at

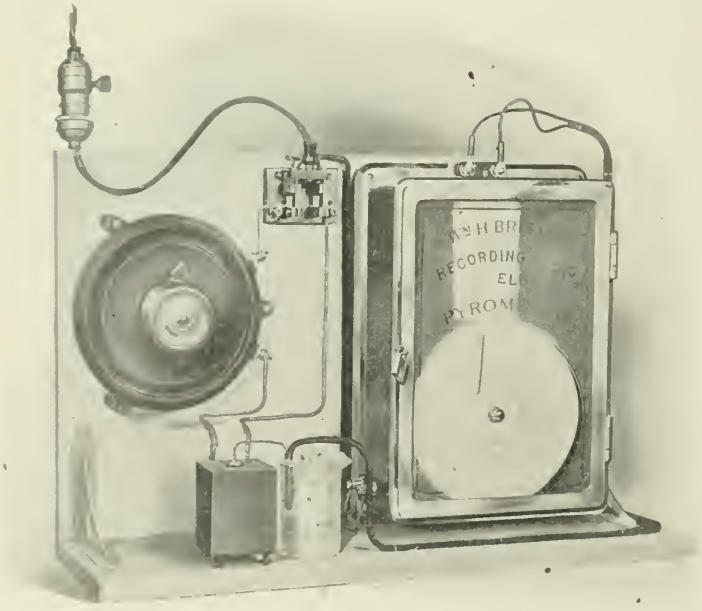


FIG. 2.—ELECTRIC FURNACE AND RECORDING PYROMETER FOR DETERMINING RECALESCENT POINTS OF STEEL.

about 1,300° F., and the other one for cooling at about 1,240° F. This shows that to harden this lot of steel, a temperature higher than 1,300° F. should be used. Sample No. 19 was a low carbon steel having different recalescent points. Sample No. 18 was cast iron and shows a point of retardation for cooling only.

It will be observed with reference to Fig. 3 that the complete test of each sample was finished in less than 15 minutes after starting with a cold piece of steel, and that the critical points of the heating and cooling curves were recorded within 7 minutes of each other. It has been found by experience that the curves obtained for these small samples with this outfit have the same characteristics and give the same results as those obtained by using large masses of metal, which would require considerable time for heating and cooling.

From the curves and recalescent points shown in the chart in Fig. 3, it is evident that the temperatures which would be right to harden one kind of steel would not be the right one to produce good results with another kind of steel. By making tests like those described above, the manufacturer can find out what temperature is the best one for him to use in hardening each particular lot of steel. The old-fashioned idea that steel could be hardened by guess-work is fast giving away to the realization that a piece of steel may become either worthless or precious, according to what heat treatment it receives.

The special laboratory outfit described above is being manufactured by Wm. H. Bristol, at 45 Vesey Street, New York City.

Notes.

American Electrochemical Society.—At the meeting of the Board of Directors, held on Sept. 28, in Philadelphia, the following gentlemen were elected members of the Society: Walter G. Clark, president Parker-Clark Electric Co., New York City; Dr. George F. Kunz, gem expert, Tiffany & Co., New York City; Harvey E. Walters, electrician, Pennsylvania Railroad Co., Altoona, Pa., and Frank S. MacGregor, Huff Electrostatic Separator Co., Hyde Park, Mass.

Erratum.—The name of the manufacturers of the various alloys for steel manufacture, described on page 429 of our October issue, is Hermann Essing & Co. In the twelfth line of the note the word sulphur should be substituted for silver.

Manufacture of Vases in Cast Silica.—In a French contemporary we notice a description of a furnace whose inner surface is shaped so as to conform with the exterior surface of the silica article to be manufactured. The furnace is filled with sand, within which is embedded the carbon resistor, which is hollow and has perforated walls so that air may be blown through the holes. When the carbon is raised to red and then white heat, the layer of sand next to the resistor is fused. The excess sand is then taken out, and by continuing the heating the molten sand is completely vitrified. Air blown in through the carbon then blows the vitrified layer outwards and presses it against the side of the furnace, moulding it to the same shape. Objects prepared by this method have a shot color, caused by the innumerable air bubbles enclosed in its mass. These objects, like those made of cast quartz, are capable of standing very great and sudden variations in temperature without cracking.

Modern Welded Pipe.—For the users of a product nothing can be more instructive than a concise outline of the methods by which this product has been manufactured, since these methods determine to a large extent its possibilities or limitations. For this reason a little pamphlet recently issued by the National Tube Co., of Pittsburg, on "The Manufacture of Modern Welded Pipe," should prove very useful, as the description of the progressive operations from ore to finished steel pipe is very clear (although, of course, only general and popular in nature) and profusely illustrated by instructive illustrations. In the process by which 4,000 tons of soft steel ("ingot iron") are made per day by the National Tube Co., the pig iron as tapped from the blast furnace is conveyed in ladles to the 300-ton mixer from which the Bessemer converters are supplied, and the National Tube Co. has succeeded in obtaining unusual uniformity in the composition of their pipe steel; the variation in carbon does not exceed 0.01 per cent from one year's end to the other. This uniformity of product is, of course, of great importance for the welding qualities of the steel, and, further, in reducing the danger of corrosion. The numerous illustrations in the pamphlet are exceedingly pretty.

Colorado College.—Mr. Clyde T. Griswold, E. M., has just entered upon his duties as professor of mining and metallurgy at Colorado College. He succeeds Dr. Thomas T. Read, who accepts the position of professor of metallurgy at the Imperial University in Tientsin, China. Prof. Griswold is a graduate of Amherst College and Columbia University, and was connected for some time with the Canadian Copper Co. Before coming to Colorado College he was superintendent of the Crean Hill Mine, at Victoria Mine, Ontario. He has been connected for some time with this concern, and just before coming to Colorado College was acting as superintendent of construction on their new smelter rearrangements and additions, which were estimated to cost $1,000,000 when completed.

Nitrogen from Air.—According to the London *Electrical Engineering*, Oct. 3, the Government of Bavaria has granted a concession to the Cyanid-Gesellschaft, of Berlin, which is affiliated with the Siemens-Schuckert Co., to utilize the water power of the Alz River at Trostberg. About 15,000 hp. can be obtained from this source. The process to be used is that of Prof. Frank, of the Technische Hochschule at Charlottenburg, in which calcium carbide is converted into calcium cyanamide, the cyanamide being employed as a fertilizer. The same company are already engaged in building a similar works near Bromberg, in the province of Posen, where they are developing 2,000 hp. A project of still greater importance is that of the Badische Anilin und Soda-Fabrik, by which it is intended to extract nitrogen from the air by the Birkeland-Eyde process, using electric discharges. The chief feature of the undertaking is the damming of the Alz River at a point lower than the project above referred to and diverting the water into the Salzach. This will give a large fall and make the power station the largest in Germany. The Mannheim Co. are meeting with considerable difficulties, owing to the peasants asking a very high price for their land. The Bavarian Government are also hesitating whether to grant a charter in view of the plans already mentioned.

Concentration and Briquetting of Iron Ores.—Under this title the American Gröndal-Kjellin Co., of 45 Wall Street, New York City, have just issued a well written and well illustrated pamphlet on the Gröndal processes. We published a paper by Mr. P. McN. Bennie on these interesting processes in our April issue.

Society of Detroit Chemists.—The Society of Detroit Chemists has recently held its first regular meeting, at which Prof. F. D. Campbell, of Ann Arbor, gave an informal talk on "Portland Cement." The Society was formed in the spring of 1907, and has on its list approximately 100 members. With the varied number of industries now located in Detroit it was found when the effort was made to start this Society that an unusually large number of men responded. The Society is an independent organization, whose aims are the furtherance of chemical knowledge, to afford opportunities for the interchange of ideas and for the discussion of all matters bearing upon the science of chemistry.

New Steel Process.—In an article in our September issue, page 344, on the Lash steel process, we stated that the process is to be tested in several industrial electric furnace plants in

Europe, and mentioned among them the Héroult plant in Remscheid. We are informed that the latter note is incorrect, but that a number of electric furnace tests of the Lash process are to be made abroad in the near future.

The Wilson-Maeulen Co. will remove, on Nov. 1, their offices from 110 Liberty Street, New York, to Prince Bay, N. Y. It is the intention of the company in the future to give increased attention in the direction of examination into individual requirements, and they state that they are now in a position to have a practical man call at any works in any part of the country, so that in making installations of pyrometers they can meet existing conditions.

Induction Furnace.—The last volume of the *Transactions* of the American Foundrymen's Association (Philadelphia meeting, 1907) contains an anonymous, but well-written and impartial, article on "the induction furnace for the production of steel by electricity." An elementary description of the fundamental principle of construction and operation is given. It is pointed out that to compensate somewhat for the low power factor it is necessary to use primary current of very low frequency. "This means that special current-generating apparatus will be required, costing from 50 to 75 per cent more than standard generators usually carried in stock by the electrical manufacturing companies. It is also impossible to obtain current for any other type furnace from the central station power plants without using very expensive changing apparatus." The well-known advantages of the induction furnace are then also pointed out. The arrangement of the plant adopted at Gysinge, Sweden, is then described and a comparison is made with the crucible process. It is shown that the induction furnace is perfectly adapted for the production of the finest grades of steel. As to the rapidly increasing demand for large ingots of crucible-steel quality, it is said that "the induction furnace solves this problem, for it is as easy to make a 2-ton charge in such a furnace as a 90-pound charge in a crucible." Figures are given as to cost, showing the great economy of the induction furnace process over the crucible process. Finally, a comparison is made with open-hearth practice. A 730-kw. induction furnace yields 30 tons daily with cold charges and 36 tons with molten charges; 590-kw. hours per ton are consumed in the former case and 490 in the latter case.

Electrolytic Refining in Australia.—With reference to our note on page 248 of our June issue, the following quotation from a recent issue of London *Electrical Review* is interesting, which gives some confirmatory and supplementary information. "At one time it was expected that the Mount Morgan Co. would build its own smelting and refining plant, but instead of doing so it has taken £50,000 interest in the Electrolytic Refining & Smelting Co. of Australia, formed early this year in Sydney, with a capital of £150,000. At present the Mount Morgan Co. sends its blister copper to America for electrolytic treatment and the recovery of the gold, which, of course, takes many months for freightage and treatment before cash is received for shipments; but the new company will not only treat the Mount Morgan blister copper, but probably also that of the Mount Lyell and other Australasian mines. Captain Richard, general manager of the Mount Morgan mine, has been in America visiting many of the largest electrolytic and smelting works in the United States. He has had plans prepared for erecting works at Port Kembla, of which Mr. B. Magnus, manager of the electrolytic refinery of the Calumet and Hecla mine, is to be the manager. Last year Mr. Magnus built the new electrolytic plant of the Mountain Copper Co., near San Francisco. It will be distinctly to the advantage of Australasian copper mining to have a local electrolytic refinery and smelters to which Australian matte can be consigned for treatment instead of having to bear the expense of shipment to the United States and the delay in realization; besides, it will be a great gain, as much of the copper produced can be sold in the Eastern markets, to which it has to be reshipped from America. It is noticeable that the Mount Morgan, while only treating some 7,500 tons of ore per month, has an output of over 400 tons of blister copper. The Mount Lyell, on the other hand, treats about 33,000 tons of ore per month for about 600 tons of blister copper. Then there is the Great Cobar, treating about 14,000 tons of ore per month for about 400 tons of blister copper. This, along with South Australian, Queensland, and other copper mines, should open up a fine field for the new refining and smelting company. The Mount Morgan mine, as a copper producer, is merely in its infancy, as with its 6,000,000 tons of payable copper ore in reserve, it in time will become by far the greatest copper mine in Australasia."

Dr. Hans Goldschmidt's many friends and admirers in this country will be pleased to hear that the distinguished inventor of aluminothermics is again on a visit in this country, in the interest of both the Goldschmidt Thermit Co. and the Goldschmidt Chemical Co.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

Calcium Carbide (*Continued.*)

No. 596,999, Jan. 11, 1898, James E. Hewes, of Philadelphia, Pa.

Adds manganese dioxide to the carbide charge, to assist the reaction, prevent escape of volatilized calcium, render fine sub-division and an excess of carbon unnecessary, prevent honeycombing of the product, minimize mechanical losses and increase the output. The preferred charge consists of carbon, 26; calcium oxide, 64; calcium carbonate, 8, and manganese oxide, 2. The flux may be introduced as briquets, pastils or cakes, with or without additional carbon and lime and a carbonaceous binder. The charge may be smelted in an arc furnace 4 feet long, 4 feet wide and 3 feet high, using a direct current of 2,400 amps. at 70 volts. The flux is basic in reaction, and combines with phosphorous and sulphur in the coke to produce phosphides and sulphides, as of calcium, which remain as a slag or crust on the carbide product. When the charge is partially smelted and molten the upper electrode is lowered into the mass and the current then flows without arcing. The product is calcium carbide containing some manganese carbide, which reacts with water to give methane. The mixture of acetylene and methane may be burned without clogging the burner.

No. 601,366, March 29, 1898, C. L. Wilson, C. Muma, J. W. Unger, H. Schneckloth, A. P. Brosius and J. C. Kuchel.

Lime and carbon are mixed and compressed into cylindrical sticks, which are connected end to end by hooks. A number of its connected sticks are placed in a long sleeve or tube of pasteboard, asbestos or metal, and the whole is fed endwise into an arc. Two sets of the inclosed sticks may be fed through hollow electrodes, between whose opposed ends an arc is sprung, or one or two sets, at right-angles to the electrodes, may be fed transversely into the arc. The sticks may be fed horizontally, vertically or at an angle of 45°. The sticks may have transverse openings to enable the heat of the arc to act more rapidly on the mixture. The hooks meet and add an insignificant amount of metal to the carbide product. In a modified apparatus a granular or pulverized mixture of lime and carbon is fed downward through a hollow vertical electrode into an arc sprung to a disc electrode beneath. The bottom and sides of the smelting chamber are covered with pulverized carbide, which receives the molten product and prevents it from adhering to the casing or base.

(*To be Continued.*)

NEW BOOKS.

Standard Handbook for Electrical Engineers.—By R. C. Beardsley, Louis Bell, H. M. Hobart, Otis Allen Kenyon, Edward Lyndon, A. S. McAllister, Kempster B. Miller, William H. Onken, E. F. Roeber, George Shaad. Twenty sections: Units, circuits, instruments, and measurements, materials, magnets, transformers, generators, motors, batteries, central stations, transmission and distribution, illumination, electric traction, electrochemistry, telephony, telegraphy, miscellaneous applications of electricity, wiring, standardization rules, tables and statistics. Bound in flexible morocco; over 1,300 pages, and 1,260 illustrations. Price, $4.00 net, postpaid. New York: McGraw Publishing Co.

Electro-Analysis.—By Edgar F. Smith, professor of the University of Pennsylvania. Fourth edition, revised and enlarged. 336 pages; 42 illustrations. Bound in limp leather. Price, $2.50 net. Philadelphia: P. Blakiston's Son & Co.

Transactions of the American Electrochemical Society. Vol. XI: Proceedings of the eleventh general meeting, held at Philadelphia, May 2, 3 and 4, 1907. 426 pages; illustrated. Bound in cloth; $3.00 net; to colleges, libraries, technical societies and journals, $2.00 net; to members $2.50 net. South Bethlehem, Pa.: The American Electrochemical Society.

Die Elektrochemische und Elektrometallurgische Industrie Grossbritanniens.—By John B. C. Kershaw, translated into German by Dr. Max Huth. 180 pages; 87 illustrations and 10 tables. In paper cover. Price, marks 9 (retail price in New York $3.00); Halle a S: Wilhelm Knapp.

Die Eisenhüttenchemie.—By Max Orthey. 258 pages; 36 illustrations. In paper cover. Price, marks 8 (retail price in New York $2.65); Halle a S: Wilhelm Knapp.

The Chemistry of Commerce. A simple interpretation of some new chemistry in its relation to modern industry. By Rob Duncan. 277 pages; illustrated. Bound in cloth. Price, $2.00 net. New York: Harper & Bros.

Recent Cyanide Practice.—Edited by T. A. Rickard. (With contributions by E. G. Banks, F. L. Bosqui, H. T. Brett, R. Gilman Brown, L. M. N. Bullock, Charles Butters, G. A. Denny, A. E. Drucker, E. M. Hamilton, Francis J. Hobson, Bertram Hunt, Alfred James, H. Julian, A. P. Kennedy, Mark R. Lamb, William Magenau, E. H. Nutter, T. A. Rickard, E. A. H. Tays, Carlos W. Van Law.) Reprinted from articles appearing in the *Mining and Scientific Press* during 1906 and 1907. 350 pages; illustrated. Price, $2.00. San Francisco, Cal.: *Mining and Scientific Press.*

A Manual of Fire Assaying.—By Charles H. Fulton, president of the South Dakota School of Mines. 178 pages; 44 illustrations. Bound in cloth. Price, $2.00, postpaid. New York: Hill Publishing Co.

Simple Chemical Experiments.—By T. T. Baker. 72 pages; illustrated. Price, 25 cents. New York: Spon & Chamberlain.

Immunochemistry.—The application of the principles of physical chemistry to the study of the biological antibodies. By Svante Arrhenius. Being a summary of six lectures on the immunity reactions, delivered at the University of California in 1904. (These lectures illustrate the application of the methods of physical chemistry to the study of the theory of toxins and antoxins. Arrhenius has made a careful analysis of the great work done by the German and French scientists and the totally different deductions they have drawn from their premises. An index of authors and an index of matter makes it possible to use the work to advantage for reference.) 309 pages. Bound in cloth. Price, $1.00 net. New York: The Macmillan Co.

The Chemical Character of the Process of Fertilization and its Bearing Upon the Theory of Life Phenomena.—By Jacques Loeb. 80 pages. Paper cover. Price, 25 cents. Berkeley, Cal.: University of California Press.

Hand Book of Technical Microscopy. By T. F. Hanausek. Translated into English by A. L. Winton. Bound in cloth. Price, $5.00. New York: John Wiley & Sons.

Electric Power Transmission. A practical treatise for practical men.—By Dr. Louis Bell. Fifth edition, revised and enlarged. 723 pages; illustrated by tables and diagrams. Bound in cloth. Price, $4.00. New York: McGraw Publishing Co.

Elementary Lessons in Heat. Fourth edition, revised and enlarged.—By S. E. Tillman. 178 pages; illustrated by tables and diagrams. Bound in cloth. Price, $1.50 net. New York: John Wiley & Sons.

The Finances of Gas and Electric Light and Power Enterprises: Electric railways, electric light stations, gas works, oil motor cars.—By W. Dennis Marks. 540 pages; illustrated by tables and diagrams. Bound in cloth. Price, $4.00. New York: William D. Marks.

Studies on the Thermodynamics of the Atmosphere.—By F. H. Bigelow. Paper cover. Price, 25 cents. Washington, D. C.: United States Office of the Superintendent of Documents.

After Earthquake and Fire. A reprint of the articles and editorial comment appearing in the *Mining and Scientific Press* immediately after the disaster at San Francisco, April 18, 1906. 194 pages; illustrated. Bound in cloth. Price, $1.00. San Francisco, Cal.: *Mining and Scientific Press.*

BOOK REVIEWS.

Electro-Analysis. By Edgar F. Smith, Professor of Chemistry at the University of Pennsylvania. Fourth edition, revised and enlarged. 336 pages, with 42 illustrations. Price, $2.50 net. Philadelphia, Pa.: P. Blakiston's Son & Co.

This book by Prof. Smith on electro-analysis is so well known from its former editions that nothing need be said concerning its general scope and character. Every American chemist is proud of Dr. Smith and his work. But much could be said concerning the new features of this fourth edition. The greater portion of the new material included in it refers to the rapid precipitation and separation of metals, the use of a mercury cathode with rotating anode and the employment of a new cell in the determination of cations and anions.

"The section describing the determination of cations and anions cannot fail to excite interest and inquiry. That the estimation, for example, of barium and chloride, in barium chloride, may be made in an hour or less, while hours would be required by time-honored methods, will naturally lead one to pause. The neatness and accuracy of such determinations also recommend them. The determination of the ferro and ferri-cyanogen and other anions indicates still greater possibilities in the application of the current to analysis."

The book is fully up to date. The very latest proposals regarding the value of graded potential in separations and the possibility of effecting organic combustions by means of the electric current receive ample consideration.

What gives the book its particular charm is the fact that the man who describes these fascinating latest developments in electro-analysis is also the man who did the work. When at the last Philadelphia meeting of the American Electrochemical Society, Dr. Smith gave an informal talk on these recent developments, Prof. Chas. F. Chandler said: "Dr. Smith's story is a novel, and is the most interesting chemical

∴ ∴ THREE NEW BOOKS ∴ ∴

12mo, Cloth *495 Pages* *Price, $2.50 Net*

VAN NOSTRAND'S

Chemical Annual

A Hand-Book of Useful Data for Analytical, Manufacturing and Investigating Chemists, and Chemical Students. Based on Biedermanns' "Chemiker Kalender"

Edited by Prof. J. C. OLSEN, A.M., Ph.D

Polytechnic Institute, Brooklyn; Formerly Fellow Johns Hopkins University; Author of "Quantitative Chemical Analysis, by Gravimetric, Electrolytic, Volumetric and Gasometric Methods."

With the Co-operation of Eminent Chemists

First Year of Issue, 1907

The absence of a comprehensive reference book of numerical data of the Science, has induced the publishers to undertake the publication of this Annual, which it is their intention to issue, *with new data, added annually.*

8vo, Cloth *250 Pages* *Price, $1.50 Net*

Chemical Reagents, Their Purity *and* Tests

A New and Improved Text Based on and Replacing the Latest Edition of KRAUCH'S

"Die Prüfung Der Chemischen Reagentien Auf Reinheit"

By E. MERCK

Authorized Translation by Henry Schenck, A.B. (Harvard)

This Book supplies a pressing need of an authoritative, practical standard, having successfully withstood years of use by both manufacturers and consumers.

Translation entirely rewritten, and much obsolete matter of previous editions omitted. The typographical arrangement is very plain, the salient points of any Reagent appearing at a glance. The exact conditions of each test have been laid down, and limitations and definitions have been given for many hitherto uncertain expressions, such, for example, as "unweightable residue." References are given, first to the original articles, then to abstracts of those articles in standard English publications.

Logarithms, factors for calculations, synonyms, atomic and molecular weights, etc., have been incorporated in the text.

8vo, Cloth *167 Pages* *Price, $2.50 Net*

Fuel, Water *and* Gas Analysis

For Steam Users

By JOHN B. C. KERSHAW, F.C.I.

"Author of Smoke Prevention"

With 50 Illustrations

CONTENTS

Fuels: Origin. Physical and Chemical Characteristics of Wood, Peat, Lignite, Bituminous Coal, Semi-Anthracite, Anthracite, Coke. Liquid Fuels. Briquette Fuels. Sampling. Apparatus for Analysis. Special Tests. Apparatus and Methods for Calorific Valuation. Practical Applications of Test Results.

Water: Sources. Physical and Chemical Characteristics of Well Waters, River Waters, Surface Waters and Rain Water. Apparatus and Methods for Analysis. Special Tests for Oil. Practical Applications of Tests Results. Use of Softening Apparatus and Reagents.

Waste Gases: Physical and Chemical Characteristics of Waste Gases. Collecting Gas Samples. Apparatus and Methods for Analysis. Applications and Use of Continuous and Recording Gas-testing Apparatus. Practical Applications of Gas Test Results.

Appendix: Rules for Sampling Fuel. Formula Calculating the Calorific Value. Use of Fuels of Low Calorific Value. Typical Tests of Exit Gases, etc. Index.

D. VAN NOSTRAND COMPANY

Publishers and Booksellers

23 Murray and 27 Warren Sts., New York

paper I have ever listened to." And Prof. W. D. Bancroft added, "that it is not any exaggeration at all to say that practically all the recent improvements in electrolytic analysis have come from the John Harrison Laboratory of the University of Pennsylvania."

Every analytical chemist, every electrochemist—no, every chemist—will rejoice that in Dr. Smith's new edition of his book we have a concise, yet complete, review of the results of all this immense amount of work. There can be hardly any doubt that Dr. Smith's high-speed analytical methods will be received by practical analysts with the same amount of enthusiasm which has marked the reception of high-speed tool steels in machinery workshops, and that a corresponding revolution in the methods of analytical workshop methods will thereby be inaugurated.

* * * * *

Uber die Elektrolytische Gewinnung von Brom und Jod. By Dr. Max Schloetter. 50 pages, with 18 illustrations. Price, marks 2.40 (retail price in New York 80 cents). Halle a. S.: Wilhelm Knapp. (Volume XXVII. of German Monographs on Applied Electrochemistry.)

This monograph is a concise summary of the different processes which have been proposed or introduced into practice for the electrolytic production of bromine and iodine, most of the descriptions being based on patent specifications. To those interested in manufacture of bromine and iodine the book should prove useful.

Thirty-seven pages of the book refer to bromine, 13 pages to iodine. As to bromine, the chemical methods of Frank and the process of the Leopoldshall Co.'s are first briefly described, as well as the later Neustassfurt process, in which liquid chlorine is used. Of electrolytic methods those of Wünsche (Westereglen), Höpfner, Nahnsen, Kossuth, Mehns and Pemsel are described, and a few words (fourteen lines together) are said concerning the process of the Dow Chemical Co. and a process of A. G. Betts. As to iodine, the electrolytic processes of Parker & Robinson and of Engelhardt are described. Notes are added on the purification and analysis and on the properties and uses of bromine and iodine.

* * * * *

Electrochemistry of Organic Compounds. By Dr. Walter Löb. Authorized translation by H. W. F. Lorenz, A. M., Ph. D. 308 pages; 10 figures. Price, bound in cloth, $3.00. New York: John Wiley & Sons.

Although this second English edition from the third German was issued some time ago, it deserves, even at this belated date, special mention, as representing characteristically the surprising progress of electrochemistry in only one branch of chemical science. The previous edition has been entirely rewritten and rearranged, a new chapter has been added on the theoretics of organic chemistry, another on methods, another on electric endosmose, and a whole new section of fifty-three pages has been added upon electrothermic processes and the silent discharge, comprising chapters on the spark discharge and the voltaic arc, the utilization of current heat in solid conductors, and the chemical effects of the silent discharge and of Tesla currents.

The translation is skillfully done, the typography of the book is attractice; and, altogether, English-speaking electrochemists and organic chemists are to be congratulated on having so excellent a work at their disposal.

* * * * *

Department of Commerce and Labor, Bureau of the Census. S. N. D. North, Director. Bulletins 81 to 88. Washington, D. C.: Government Printing Office.

All these bulletins which have just been issued are parts of the Census of Manufactures for 1905. Bulletin 81 refers to shipbuilding; 82 to musical instruments, attachments and ma-

terials; 83 to slaughtering and meat packing, manufactured ice and salt; 84 to carriages and wagons and the steam and street railroad car industry; 85 to pens and pencils, buttons, needles, pins and hooks and eyes, oilcloth and linoleum, and turpentine and rosin; 86 to copper, lead and zinc smelting and refining; 87 to tobacco; 88 to power employed in manufactures.

From bulletin 86, prepared by Story B. Ladd, we gather the following interesting data. In all the different copper, lead and zinc smelting refining plants the value of the products in 1900 and in 1905 was as follows:

	1900.	1905.
Copper	$105,131,670	$240,780,216
Lead	175,476,304	185,820,830
Zinc	18,188,498	24,791,209

It will be seen that the increase in copper was 45.8 per cent, in lead 5.9 per cent, in zinc 36.3 per cent, and that the relative position of copper and lead has been reversed between 1900 and 1905. This is also shown by the facts that the increase in capital in both the copper and zinc industries has been large in the same period, whereas in the lead industry there is shown a decrease. The same holds true of the average number of wage-earners employed.

It is to be considered however, that the statistics of the copper and lead smelting industries are colored by the practice of smelting dry ores of the precious metals along with base ores, and a large increase in the consumption of dry ores by copper smelters at the expense of the lead smelters has helped to swell the growth of the copper smelting and refining industry. This is a point on which we commented in an editorial note in November, 1905 (our Vol. III., p. 407). It is brought out in an instructive way in the following figures, which give the gold and silver production of the copper smelting and refining and lead smelting and refining industries for 1900 and 1905. The figures are also given for the copper product of the former industry, exclusive of Lake copper, and the lead product of the latter industry, exclusive of soft lead—which exclusions are made for the reason that dry ores, so called, are not smelted in conjunction with Lake copper ores or "mineral" or soft lead ores:

Copper Smelting and Refining.

	1900.	1905.
Silver, ounces fine	13,229,911	28,115,790
Gold, ounces fine	224,352	636,207
Copper, not including Lake copper, pounds	444,654,289	728,620,488

Lead Smelting and Refining.

	1900.	1905.
Silver, ounces fine	70,420,917	71,920,997
Gold, ounces fine	2,514,836	2,543,757
Lead, not including soft lead, pounds	497,455,031	613,331,956

It will be seen that the increase in the gold and silver products of the copper industry was very large (increase in silver 113 per cent, gold 184 per cent) and greatly in excess of the increase in the related copper product (63.9 per cent), whereas the gains in the gold and silver products in the lead smelting and refining industry are very small and fall far below that for the related lead product. As we have pointed out before, the increase in the consumption of dry ores by copper smelters appears to be due in part to the development of electrolytic copper refining, whereby gold and silver values are easily and cheaply recovered, and also due to the fact that, in the rapid advance in the art of matte smelting, copper has proved to be on the whole a better absorbent of the precious metals than lead.

The number of copper smelting and refining works has decreased from 47 in 1900 to 40 in 1905, the capital invested has increased from $53,063,395 to $76,824,640, and the value of products from $105,131,670 to $240,780,216.

Just Ready

Electro Analysis

By EDGAR F. SMITH, M.A., Ph.D., Sc.D.
Professor of Chemistry, University of Pennsylvania

Fourth Edition, very completely Revised and greatly Enlarged and Improved. With 42 Illustrations. Octavo; 346 pages. Limp Leather. $2.50 *net*.

Synopsis of Contents

Introduction.—Sources of Electric Current: *Magneto-Electric Machines, Dynamos, Thermophile, Storage Cells.*—Reduction of the Current: *Rheostats, Resistance Frame.*—Measuring Currents: *Voltameter, Amperemeter, an Electro-Chemical Laboratory.*—Historical Sketch.—Theoretical Considerations. Rapid Precipitation of Metals in the Electrolytic Way.—Use of Mercury Cathode.—Determination of Metals.—Separation of Metals.—Additional Remarks on Metal Separations.—Determination of the Halogens in the Electrolytic Way.—Determination of Nitric Acid in the Electrolytic Way.—Special Application of the Rotating Anode and Mercury Cathode in Analysis.—Oxidations by Means of the Electric Current.—The Combustion of Organic Compounds.—Index.

Descriptive Circular sent free upon request

The Food and Drug Act, 1907

Books Purchased by the Federal Government for the Use of Inspectors

Autenrieth. "The Detection of Poisons and Strong Drugs"	$1.50
Heusler. "Chemistry of the Terpenes"	4.00
Leffmann and Beam. "Select Methods in Food Analysis," 2d Edition ..	2.50
Richter. "Organic Chemistry," 3d Edition, by E. F. Smith. Two Volumes	6.00
Sayre. "Organic Materia Medica and Therapeutics," 3d Edition	5.00
Thresh and Porter. "Preservatives in Food and Food Examination" ..	4.50
Allen. "Commercial Organic Analysis," 9 Volumes	34.50
United States Pharmacopœia, 8th Revision	2.50
Sutton. "Volumetric Analysis," 9th Ed'n	5.00
Greenish. "Microscopical Examination of Foods and Drugs"	3.50

Circulars of These Books Upon Application

P. BLAKISTON'S SON & CO.
Publishers of Books on Technology, Chemistry, Biology, Pharmacy, Medicine
1012 Walnut Street Philadelphia

The number of lead smelting and refining works has decreased from 39 in 1900 to 32 in 1905, the capital invested from $72,148,933 to $63,822,810, while the value of the products has increased in the same period from $175,406,304 to $185,826,839.

The zinc industry has passed through a continuous and healthy growth during the last quarter of a century. The production of spelter, including sheet zinc, was 23,239 tons in 1880, 58,800 in 1890, 131,540 in 1900, and 180,090 in 1905.

In 1900, although the quantity of zinc made by the Western establishments exceeded the zinc output of the Eastern plants, the total value of the products of the Eastern plants was largely in excess, the latter producing $3,143,370 of zinc oxide and sulphuric acid, besides other products, in addition to spelter and sheet zinc products. In 1900 the output of the Western smelters was all in the form of spelter, while of the Eastern establishments only 67.8 per cent of the total products was spelter and sheet zinc.

In the five years after 1900 the situation has been changed, as follows: For 1905 the Western establishments show a production of 257,632,103 pounds of zinc (spelter and sheet zinc), of a value of $12,823,354, an increase of 77.4 per cent in quantity and 64.4 per cent in value over 1900, and in addition zinc oxide, sulphuric acid and other products of a value of $1,234,269. On the other hand, the Eastern works show a slight decrease in zinc metal production for 1905 compared with 1900, but an increase in other products, the total products of the Eastern smelters showing a small increase of 3.3 per cent, as compared with an increase of 80.2 per cent for the Western works. For 1905, zinc metal constituted 59.5 per cent of the total products of the Eastern works (against 67.8 per cent in 1900) and 91.2 per cent (against 100) of the product of the Western.

We have taken from the report only the most general figures and those which show general tendencies in the development of the metallurgical industry of this country. Concerning detailed figures, especially statistics arranged according to States and Territories, the reader must be referred to the original bulletin. Many of our readers will also find much of interest in bulletins 83 and 89, containing, respectively, reports by Prof. Charles E. Munroe on the manufacture of salt, and by Mr. T. C. Martin on power employed in manufactures.

* * * * *

Transactions of the American Electrochemical Society. Volume XI. 426 pages; illustrated. Price, $3.00 net. To colleges, libraries, technical societies and journals, $2.00 net. South Bethlehem, Pa.: The American Electrochemical Society.

This is one of the largest volumes so far issued by the American Electrochemical Society. It covers the proceedings of the meeting held in Philadelphia in May, 1907, and contains thirty papers. Since full abstracts of all which were read at the meeting were given in our June issue, we will mention here only those which were read by title and now appear in the *Transactions* for the first time in print. These are a well-written biographical sketch of Moissan, from the pen of G. F. Kunz, and an interesting and suggestive discussion, by W. McA. Johnson, of the electrometallurgy of zinc and its relation to present practice. The latter paper covers about the same ground, though in greater detail, as the same author's article in our March issue (page 83 of our present volume).

In re-reading Mr. Carl Hering's presidential address, we are reminded of the fact that there once was a scheme which, in its consequences, would have changed the Society practically into the electrochemical section of the American Chemical Society. From the fact that nothing whatever has been heard of it again we may conclude that the scheme has died a well deserved natural death. Certainly the success of the Philadelphia meeting and of the recent New York meeting indicate that the American Electrochemical Society is strong enough to do excellent work as an independent organization. President C. F. Burgess' picture appears as frontispiece.

PALMER—*Practical Test-Book of Chemistry.* Including Specific Tests and Tests for Purity. 12mo, x + 190 pages. Cloth, $1.00.

Extract from Preface.—"In collecting these Tests and arranging them alphabetically, an effort is made to supply physicians engaged in practice, and pharmacists, with a ready means and safe guide for testing any substance presented for examination. And as only practical information is aimed at, the methods employed are very simple and form a series of unpretentious experiments."

GOOCH-BROWNING—*Outlines of Qualitative Chemical Analysis.* Small 8vo, vi + 145 pages. Cloth, $1.25 net.

MORGAN—*The Elements of Physical Chemistry.* Third Edition, Revised and Enlarged. 12mo, xii + 510 pages, 21 figures. Cloth, $3.00.

MORGAN—*Physical Chemistry for Electrical Engineers.* 12mo, viii + 230 pages. $1.50 net.

JOHN WILEY & SONS

43 & 45 E. 19th St. New York City

Eleventh Edition

Metallurgy of Cast Iron

A complete exposition of the processes involved in its treatment, chemically and physically, from the blast furnace through the foundry to the testing machine, being a practical compilation of original research.

By THOMAS D. WEST

Contents

PART I.—Manufacture and Use of Coke—Properties in Ores—Operations of Blast Furnaces—The Different Brands of Pig-Iron and How to Purchase and Use Them Intelligently (27 chapters). II.—Elements in Cast-Iron and Their Physical Effect—Utility of Chemical Analyses and How to Use Them in Making the Different Mixtures of Irons Used in Making Gray and Chilled Castings (21 chapters). III.—Properties of and Methods for Testing Molten Iron—Phenomena in the Actions of Cooling Metal, etc.—Results of Tests in All Kinds of Irons—Best Methods for Testing (23 chapters). APPENDIX. Selected Tables for Use in Furnace and Foundry Work.

Cloth 638 Pages 153 Illustrations Price, $3.00 net

Sent Anywhere, postpaid, for the Price by the

McGRAW PUBLISHING COMPANY

239 West 39th Street :: New York

Electrochemical and Metallurgical Industry

VOL. V. NEW YORK, DECEMBER, 1907. No. 12.

Electrochemical and Metallurgical Industry

With which is Incorporated Iron and Steel Magazine

Published on the first of each month by the
ELECTROCHEMICAL PUBLISHING COMPANY,
[*Incorporated.*]
239 WEST 39TH STREET, NEW YORK.

J. W. RICHARDS, PH D .....*President*
E. F. ROEBER, PH. D .....*Editor and Secretary*
C. E. WHITTLESEY.....*Treasurer*

Subscription Price: $2 per year, postpaid to any part of the world. Single copies 25 cents.

Copyrighted, 1907, by the Electrochemical Publishing Co.

Entered as Second-Class Matter, June 1903, at the Post-Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, DECEMBER, 1907.

CONTENTS.

EDITORIAL 485
Subscription Rate 485
Nitric Acid from Air. 485
The Iron Situation 486
Cost of Mining..... 487
IRON AND STEEL MARKET..... 488
Mendelejeff Congress of Chemistry 489
Electric Zinc Smelting. By F. T. Snyder. 489
Faraday Society 489
CORRESPONDENCE:
Presidency of the American Electrochemical Society. By Charles F. Chandler, Charles M. Hall, Samuel S. Tucker, Carl Hering 490
Nitric Acid from Air. By J. Moscicki..... 491
Vanadium. By J. Kent Smith 494
Technical Analysis of Vanadate of Iron. By Arden M. Wilson 495
METALLURGICAL CALCULATIONS (Electric Smelting of Copper Ores) By J. W. Richards..... 496
Physical Factors in the Metallurgical Reduction of Zinc Oxide. By W. McA. Johnson 498
Application of the Laws of Physical Chemistry in the Metallurgy of Iron. II. By H. von Juptner 500
NOTES ON ELECTROCHEMISTRY AND METALLURGY IN GREAT BRITAIN 502
ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS 504
RECENT METALLURGICAL PATENTS 506
SYNOPSIS OF PERIODICAL LITERATURE 509
Titanium in Steel Metallurgy 511
Standardization 512
Ferro-Alloys in the Foundry..... 512
Valve 513
The Floating Battery 514
NOTES 514
DIGEST OF UNITED STATES PATENTS (Calcium Carbide) 516
NEW BOOKS 517
BOOK REVIEWS:
W. A. Noyes Kurzes Lehrbuch der Organischen Chemie 517
R. Pitaval's Annuaire Universel des Mines et de La Metallurgie 518
J. H. Stansbie's Introduction to Metallurgical Chemistry for Technical Students 518
H. W. Wiley, on Foods and Their Adulteration 519
Harper's Electricity Book for Boys..... 519
Leo H. Baekeland's A Family Motor Tour Through Europe . . 520

Subscription Rate.

While in the past the yearly subscription price to ELECTROCHEMICAL AND METALLURGICAL INDUSTRY has been uniformly $2.00, postpaid to any part of the world, the increase in bulk of the copies and the resulting increase of postage to foreign countries, make it necessary to charge at least part of the forwarding expenses to our foreign subscribers. The subscription price *to foreign countries* will therefore be slightly raised, and will be in future the equivalent of $2.50, *i. e.*, 10 shillings, 10 marks, or 12.50 francs, including postage. The yearly subscription price for the United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippines will remain as heretofore, $2.00.

* * *

Nitric Acid from Air.

Mr. Moscicki's account of his work on the fixation of atmospheric nitrogen, which will be found elsewhere in this issue, emphasizes the fact that there has been in recent years a change in sentiment from the spark to the arc method. Formerly sparks were considered to be more efficient than the arc for forcing atmospheric oxygen and nitrogen into a combination, but the necessity of using a great many sparks—each a small unit—necessarily led to mechanical complications and difficulties, and though these could be overcome, the first cost of the apparatus became so high as to be prohibitive. The recognition of this fact terminated Moscicki's endeavors in this direction, and also appears to have been the fundamental reason of the failure of Bradley and Lovejoy in Niagara Falls. It is clear that if a method using extended arcs can be made as effective in operation as the spark method, the former will be the more economical on account of the simpler apparatus, and hence smaller capital investment. The low efficiency of a quiet, voluminous arc results from the fact that it consists of several zones with gradually decreasing temperatures; at the place of highest temperature the concentration of nitrogen oxide in the air is a maximum, but when this gas mixture passes through the zones of lower, yet still high, temperatures, a considerable portion of the nitrogen oxide, formed before, will be dissociated. The only remedy is to bring the gas mixture at once from the zone of highest temperature to a temperature so low that the speed of dissociation is practically zero (because it is only at comparatively high temperatures that any combination of nitrogen and oxygen or, reversely, any dissociation of nitrogen oxide takes place). By quick, sudden cooling the composition of the gas mixture, corresponding to the high temperature of formation, is preserved; we might say it is frozen. This is possible by using the moving arc in which all zones but that of highest temperature are suppressed. The first success in this direction was obtained by Birkeland and Eyde with their "flaming disc." But modifications may easily be devised. The "flaming ring" of Moscicki

(and others) seems, mechanically, a very simple method, and the results obtained by him in the continuation of his work will be watched with interest. But at present we must still repeat what we have pointed out before, that the commercial success of the Birkeland-Eyde process in Europe is no criterion for the United States, since it has been achieved with a power cost—$4 to $6 per horsepower-year—so low as cannot be thought of in this country.

The Iron Ore Situation.

One would not naturally expect sentiment to exert much influence upon so great a work as the development of the iron ore resources of the United States, a work which has come to involve the movement of nearly 50 000,000 tons of ore a year, the transport of millions of tons of it over distances exceeding a thousand miles and the employment of hundreds of millions of dollars of capital in mining and transportation, yet a prospect and retrospect compels the conclusion that to a certain extent various sentiments quite apart from the engineering and metallurgical problems involved have played an important part in leading the development along the lines which have been followed rather than along other lines. The iron industry has apparently reached a point where it is out of harmony with geological and manufacturing conditions. More than 80 per cent of the iron ore it is mining is from the Lake Superior region, with only about 13 per cent from the Southern field, and about 7 per cent from scattered regions. There is more ore in the Southern field above the 1,000-foot level than there is in the whole Lake Superior region, and much more still below that level. It is true that the Lake Superior ores are better than the Southern ores, but the disparity has been decreasing year by year, and as to the average of the remaining ores there may not be much difference. As to the relative cost of mining, the advantage of the Lake Superior region has been decreasing as deposits with greater and greater overburdens must be stripped. As to transport, there is no comparison; the Lake Superior ores are moved over distances of from 750 to more than a thousand miles, while in the Southern district the blast furnace can be located at the mouth of the mine. In other parts of the United States there is unquestionably several times as much ore as there is in the Lake Superior region, but development has not been sufficient to furnish data for comparisons as to relative utility.

* * *

This one-sided development is, as has been said above, quite out of harmony with geological and manufacturing conditions. The other forces which have been at work may, perhaps, be described in a certain sense as sentimental. A decade and more ago, before the pig iron producers of the Central West had become large miners of Lake Superior ores themselves, they used to sit in the ante-rooms of the Cleveland ore firms waiting for a chance to sign ore contracts. All they had to do was to sign a contract for a year's supply, making payment in twelve monthly instalments, and receiving delivered at their furnaces ore of a selected analysis running uniformly as to chemical and physical characteristics. The demand for their pig iron was increasing rapidly, and in the problems of production and distribution and the extensions to their plants they were kept very busy. The Cleveland ore firms, and later the pig iron producers as they entered upon ore mining, had no difficulty in securing funds for development. The South, on the other hand, had the greatest difficulty in securing funds for development, a difficulty which has not disappeared, and indeed was one of the principal causes which recently forced the leading Southern interest to seek shelter under the wing of the United States Steel Corporation. There has been much room for pioneer work in other districts outside of the South, but iron manufacturers, in the field or proposing to enter, had neither time nor energy for the problems which would be presented. Then, too, there was the charm of the Bessemer process. Put 10 tons of molten pig iron into a vessel costing a few thousand dollars, blow ordinary atmosphere through it for a few minutes, and get 10 tons of pretty good steel. This could be done with three-fourths of the iron ore mined ten years ago in the Lake Superior region. It could be done with practically none of the ores mined elsewhere. In those days, with scrap a drug on the market, basic open-hearth steel of better quality than Bessemer could be produced at a less cost per ton, but the plant would cost several times as much, and in an industry which was doubling production oftener than once per decade, manufacturers were looking at profits per dollar of investment rather than per ton of output. The Lake Superior idea got such a hold upon the trade that the knowledge that far less than half the total reserves are of Bessemer grade, that the basic open-hearth process is preferable, and that there are many times as much ore elsewhere, of various intrinsic values, awaiting exploitation and development has hardly yet shaken it.

* * *

In the chapter on iron ores and iron products in the forthcoming report for 1906, the United States Geological Survey takes occasion to make some estimates of the total iron ore reserves of the United States, one of the objects being to show the absurdity of Prof. Törnebohm's summary of the world's workable iron ore, made to the Swedish Parliament a couple of years ago, and crediting the United States with but 1,100,000,000 tons out of a world total of only 10,000,000,000 tons. In brief, the Survey notes that the Lake Superior region has between 1,500,000,000 and 2,000,000,000 tons, that four States in the Southern district have, above the 1,000-foot level, 2,500,000,000 tons of workable ore, that the whole Southern district has, above and below the 1,000-foot level, about 10,000,000,000 tons, and that, taking into account the older Eastern States and the West, the United States may have more than 20,000,000,000 tons of workable iron ore. Everything goes to show that iron ore, *per se*, has no value whatever, the total reserves which can be worked in this way or that way being too large to write a value upon them. They will last for centuries at a greater rate of production than the present, so that with capital doubling through compound interest many times in a century the latest ores to come into use can have no present value. A given deposit of iron ore can have a present value only through its being cheaper to make pig iron from it than from other ores which will have to be used within the period in which interest charges would not become onerous. The present values which have been assumed for and written into Lake Superior ores are not in accordance with this principle. A change in the estimate of relative values is beginning to

overtake the trade. The next great period of development will take cognizance of it, and will be based most largely upon iron ore deposits outside the Lake Superior region. Its annual rate of production, which has more than quadrupled in eighteen years, is reaching the limit, because the present capital tied up in connection with it can exhaust it in less than half a century, the fees and leases are closely held by the producer-consumer class, and they have little incentive to lock up much more capital. That new period of development will hardly come soon. The present situation is that the October rate of pig iron production in the United States, which represented nearly 28,000,000 tons annually, and was the greatest rate ever witnessed, is being decreased by much more than one-half, while blast furnaces rated at fully 2,100,000 tons annually were completed and blown in this year, yet leaving furnaces with an annual capacity well beyond 3,000,000 tons in process of construction and in many cases well advanced towards completion.

Cost of Mining.

In any business enterprise the question of accurate cost-keeping is most essential and especially necessary at this time when the general tendency is to operate on a small margin with a large volume of sales. In the manufacture and marketing of high-grade machinery, a very rational system has been devised, based on the "producing hour," to which is added "overhead expenses" and profit. This is scientific and practical for it makes the unit a clear-cut business entity. It also allows of a systematic organization on the identical plan. In the smelting of ores and the refining of metallic products, the costs are figured usually per ton of ore in smelting and per ton of bullion in refining. On this unit, the costs of flux, fuel, labor, repairs, renewals and depreciation are calculated. Then the margin of "treatment charge," less smelting costs, is simply attained. In addition the "metallurgical margin," or difference between estimated recovery and actual recovery is a further source of profit. Thus it is seen that in the smelting business, accounting is on a rational basis.

* * *

Now, in the mining business we have a very logical unit, viz.: the ton of rock raised, and it is possible to make an elaborate cost sheet, covering various items, such as power, producing labor, superintendence, repairs, etc., even to the candles used per ton of ore. This is all very fine on a theoretical basis, but it is neither scientific nor practical. There are two variable factors, the cost of development work and the life of the mine. In these two respects, we have the mining business differentiated from any other business, though it resembles in a way the lumber business. But the differences are obvious. The life of a mine and the cost of development work are mutually interdependent. For when the ore is practically played out, no development work should be done, for as no ore is left, it is bad business to attempt to find it. Furthermore, where it is possible at all to estimate rightly the life of a mine from the geology of the district, as shown by older mines, it should be possible approximately to apportion the development to correspond in a crude manner to amount of ore possible and probable in the ground. We emphasize the adjectives "rough" and "crude," because usually in the mining business future profit, based on ore estimated by geological conditions, is at best a rough and crude estimate.

We have thus shown to the reader—as he is presumably a layman, it is pardonable to assume the "ex cathedra tone"—that the question of cost of "finding the ore" is most important. It can be further stated that it is usually underestimated. Thus in one mine of which we have knowledge the ore reserves were on a conservative basis $125,000. But it had taken at least $50,000 to run 2,500 feet of tunnels, drifts, raises, cross-cuts and winzes to find that amount of ore. It was only fair to charge a like amount of money to future development work against the present reserves, for in the mining business there must be no such thing as "getting a new dollar for an old one." There must be, even on most conservative basis, a good chance for future profit. Consequently the value of the mine was not over $75,000. In the development of coal fields by diamond drilling or by churn drilling, to an engineer versed in the art, it is possible to "prospect" and develop cheaply, and also to estimate tonnage accurately. This is because of the fact that the coal measures now worked in America are uniform and often quite near the surface. In the iron fields of Michigan and Minnesota, prospecting has been aided by magnetic surveying and by drilling. Drilling has also been effective in the lead districts of Southeast Missouri. Scientific and accurate churn-drilling has been done in the zinc field of Joplin and vicinity; indeed, the future of this district in the zinc business will be aided by this method of finding ore. It is especially necessary in Joplin to drill carefully, because of the pockety and erratic nature of the ore deposits and the consequent short life of the average Joplin mine. For mining men who carry on their operations with consistent drilling, the Joplin field is to the zinc business what the Mesaba range is to the iron business.

* * *

In Leadville, Butte, Bisbee and Cripple Creek the mining costs are usually figured at from $2 to $5 per short ton, according to conditions. If, however, a careful study of these districts were made, we believe that the costs should be increased from the above figures to $4 to $10 per short ton, with the proper charges for development work against probable amount of ore a given amount of development work will find. Hence an accurate study and estimate of geological conditions is necessary. The great position of Butte in the copper business and the Coeur d'Alenes in the lead-silver business is due in large part to the persistence of the mineralization in each district. This reduces the cost of development work for the entire district and consequently more money is made, as less money is wasted in futile attempts of finding ore. The great future of Ely, Nevada and Bingham, Utah, in the copper world is due to the uniformity of low-grade deposits. In conclusion, let us reiterate the fact that mines, like people, have their period of productive life, that mines at times should be "osterized," but that a mining company should continually develop new mines, so that its family of producing mines should have a permanent existence as a family should have a permanent existence. By applying synthetically to the mining business the principles of evolution found by the analytical methods of Charles Darwin, in a shrewd and cold-blooded manner but with philosophical insight, success and large profit can be attained. With the risk reduced to a minimum and the speculative chance for something great always possible, mining is a most attractive venture

The Iron and Steel Market.

November has made a record for itself in the American iron and steel trade. It will go down in history as the month which has recorded the greatest decline in production, both as to tonnage and as to percentage, which has ever been experienced.

October closed with pig iron being made at the rate of 20,000,000 tons a year; November closed with a rate under 15,000,000 tons. The rate during the first three weeks or more of October had been over 28,000,000 tons, so that in the five weeks beginning late in October and embracing the month of November there was a decline in the annual rate of pig iron production of more than 13,000,000 tons, or 44 per cent. Never before in the history of the trade has there been so great a decline in point of tonnage, and never before has there been so great a decline in percentage in anything like an equal period of time. In 1903 there was a decline of a shade over 50 per cent, but it required the seven months from May to December to accomplish this, and production being on a much smaller scale that year the decline in point of tonnage was less than 11,000,000 tons a year. There has been no other decline in the history of the trade at all comparable with the present one outside of that in 1903.

The decline in steel production has been even greater than that in pig iron. The steel industry has neither accumulated stocks of pig iron, nor drawn upon stocks, as it had practically none, so that production of steel—and of finished steel products—has moved evenly with the production of steel-making pig iron. The production of foundry iron has decreased less than that of steel-making pig, partly because the consumption has been better maintained, but chiefly because many merchant furnaces have remained in operation to give themselves and their customers some stocks, and get themselves into a comfortable position for as long a shut-down as conditions may suggest. By the 1st of December the steel trade had already experienced the greater part of its probable curtailment, while with the foundry iron industry a large decrease was still to be expected. It is quite possible that the rate of pig iron production at some time in December may fall below 10,000,000 tons a year.

For months there has been good reason to expect a sudden slowing down in production at about this time, and these reports have reflected that probability, but no ordinary causes could have produced such a wonderful curtailment in so brief a period. The financial stringency all over the country was so timed as to add a compelling force to the influences which had already come into existence. There was such a tightening of funds that consumers on the one hand could not see their way clear to meeting payments, while producers were afraid to ship. Indefinite postponement of shipment on the great bulk of orders and contracts for finished steel products immediately became the rule and for a few days in November the mails of steel producers contained little else than peremptory instructions to cease shipments.

While the future must be quite in the dark during the progress of such sweeping changes, it can be said that with the establishment of conditions calling for a cutting in half of production, not a great deal more can occur in this direction, and that with the actual movement so greatly restricted the strain on credit should be so reduced as to permit freer movements. Besides this, some actual pressing needs must be arising during this period when business is throttled. Altogether, it seems reasonable to predict a moderate improvement in buying and production by the early part of January. At the same time it is inconceivable that with such a disturbance the old order of heavy production and buying can be restored in any period of a few months. The iron and steel industry is likely to have to run at greatly reduced pressure through the major part of next year, and it may be more than a year before the rate of production of last October—which happened to be the greatest ever attained—is restored.

Pig Iron.

Sales of pig iron during November were undoubtedly the lightest for a month in many years. Only occasional small lots for prompt shipment figured at all, and there was not enough business done to establish regular market prices. Referring to asking prices rather than actual transactions, it may be said that Bessemer has declined to $19, valley; foundry iron to $18, valley, and Southern iron to $15, Birmingham, for No. 2. The decline averages about $2 a ton for the month. Present prices are purely nominal. As the majority of sellers have either blown out their furnaces or laid definite plans to do so, their real position as to prices has not been formulated. When business is resumed on a reasonable scale it is likely to be at lower prices than these, but it is not inconceivable that the level should be higher, on account of the independent position in which producers are placing themselves.

Steel.

The market has been quite uneventful. The mills have adhered to their understanding to hold billets, both Bessemer and basic, at $28, f. o. b., Pittsburg. There has been no business done at this figure, but it is doubtful if steel could have been sold at any price. Sheet bars remain at $31, Pittsburg. In some quarters there is an expectation that prices will be revised by the end of the year, but nothing definite regarding this can be known by anyone.

Finished Material.

The steel mills entered this period of universal throttling of the channels of trade with several million tons of orders on their books. Upon the great mass of this, shipment has been indefinitely postponed. Very little has been actually canceled. There has been a little new business placed, but very little indeed; and increased mill activity, if it comes, will come chiefly from the resumption of shipments upon old orders. In the main, prices have been strictly maintained, and while there may be some readjustments here and there it is probable that the steel interests will be able to hold the price level pretty steady for months, at least until the bulk of the old business has been worked off. The spirit is very strong among the producers that prices should be maintained. It is absurd to hope, however, that these prices can be maintained indefinitely. It has been repeated again and again that since prices were not advanced in time of great prosperity, they should not now be reduced. As the premises are wrong, it is unnecessary to discuss the reasonableness of the theory. Prices were advanced, but with such little friction that little heed has been taken. A price index system, devised to show the average price of finished steel products, giving each line its proper weight according to the tonnage of production, shows that the regular prices in 1902 averaged $44.00 per gross ton; that at the low points in 1904 the average was $30.71, and that present prices average $41.64. In 1897 the low points in all the history of the trade made up an average of $28.24. The present depression is not as severe as that which caused the low prices of 1897, and basic conditions are quite different, but on the other hand the present situation is a far worse one than that which produced the low points of 1904.

There has been no change in prices of finished steel products. Sheets continue to be shaded by $2 a ton from the official price of $2.60. Iron bars are quite irregular, but can be quoted at between $1.50 and $1.60, Pittsburg. The recognized prices on finished steel products remain as last quoted, f. o. b. Pittsburg, per 100 pounds:

Structural shapes, $1.70 for means and channels, 15 inches and under.

Plates, $1.70 for tank quality.

Merchant steel bars, $1.60 base.

Sheets, 28 gauge, $2.60 for black and $3.75 for galvanized.

Tin plates, $3.90 for 100-pound cokes.

Mendelejeff Congress of Chemistry.

From the 2d to the 12th of January, 1908, the first Russian Congress of Pure and Applied Chemistry will be held at St Petersburg, in memory of the late D. Mendelejeff, the celebrated Russian chemist.

Prof. A. Krakau, of the Electrochemical Institute of the Emperor Alexander III., Pesotchnaya 5, St. Petersburg, intends to use this opportunity to acquaint the members of the Congress—and ultimately, by means of public lectures, the more general classes of the Russian public—with the recent progress and the present condition of the electrochemical industry, especially in the United States.

For this reason manufacturers, using electrochemical processes, are requested to send to Prof. Krakau samples of their products, photographs of their works, and general information as to their products, prices, amount of power used, patents, etc. The exhibits thus obtained will form the nucleus of a permanent Mendelejeff Museum.

Electric Zinc Smelting

Mr. FREDERICK T. SNYDER, whose activity in introducing the electric furnace into zinc metallurgy has been repeatedly mentioned in our columns, presented a paper on electric zinc smelting at the recent Mineral Point meeting of the Tristate Mining Association.

The author gives comparative costs of zinc smelting in two plants, each of 25,000 tons annual capacity, operating under equivalent traffic conditions in the Illinois coal field, one using retorts and the other an electric stack furnace.

"The first cost of the present type of retort plant, including land, buildings and machinery, but excluding working capital, will be some $400,000. The equivalent first cost of the electric stack plant, including steam-driven electric generating machinery, will be substantially the same. Of this $160,000 is the cost of the stack plant and $240,000 the cost of the electric generating plant.

"General operating cost items for salaries, interest and depreciation are substantially the same for the retort plant and the electric furnace plant."

The operating cost in a modern retort plant burning coal with mechanical stokers is taken as $4 per ton of raw ore. The labor in an electric stack plant "may be kept well under $3 per ton," on account of the greater compactness of the plant. "With the electric stack furnace the sulphur does not have to be roasted as low as with retorts; 6 per cent of sulphur in the electric stack furnace will give as good an extraction of zinc as 1 per cent sulphur with retort furnaces."

As to fuel, "a regenerative retort plant will burn 4,200 pounds of coal per ton of raw ore. Of this 600 pounds will be used in roasting. With the electric stack furnace it takes 1,200 horse power-hours of electricity per ton of raw ore," which require about 1,800 pounds of coal. The coal required for roasting is also one-half. "The saving is substantially 1 ton of coal per ton of ore, amounting to 75 cents."

"With the retort plant 800 pounds of reduction material will be used per ton of raw ore; with the electric stack plant 200 pounds, assuming in each case a furnace charge carrying 50 per cent of zinc. With normal prices this saving amounts to 55 cents per ton of raw ore."

The author estimates that the expense of new retorts is 40 cents per ton of raw ore, which is saved in the stack plant, but the latter requires electrodes, and their cost per ton of raw ore is estimated at 20 cents.

Summing up these differences, the electric stack plant costs $2.50 less per ton of raw ore to operate than the retort plant.

The increased recovery due to the stack plant, with zinc at 4 cents, is estimated at $4 per ton ore.

"With the electric stack plant, iron in the zinc ore improves the operation of the stack furnace. Up to the point where the percentage of iron equals one-half the percentage of silica, iron is required in the stack furnace charge and has to be added if absent. With an ore running 50 per cent in zinc, and no lime, this means that an electric stack furnace requires an iron contents of 8 per cent."

"With the electric stack furnace, any lead in the ore is reduced and saved separately, at the same time as the zinc. This makes it practicable to do rougher concentrating work and let the lead go in with the zinc, taking out only the gangue. With zinc concentrates containing 3 per cent of lead, 50 pounds per ton of raw ore, or $2\frac{1}{2}$ per cent, will be saved in electric stack smelting and lost in retort smelting. At 4 cents per pound this is an item of $2.00. In addition, the lead penalty will be saved to the owner of the ore.

"Lime is required in the charge in an electric stack furnace and is permissible in the roasting, as low sulphur is not required. With limy ore this saves the penalty to the mine owner. It also makes a saving of zinc, as with no lime penalty close work is not so imperative, and less zinc is lost in the mill tailings. These items may reach $1.50 per ton.

"Summing up these savings of metals in the electric stack plant over the results of a retort plant, makes a total of $7.50 per ton of shipping ore. This taken together with the reduction of operating expense, makes a net difference between the retort plant and the electric stack plant of $10.00 per ton of ore."

Faraday Society.

The thirty first ordinary meeting of the Faraday Society was held on Oct. 29 at the Institution of Electrical Engineers, in London, Mr. N. T. M. Wilsmore in the chair.

The chairman announced that SIR OLIVER LODGE has accepted the invitation of the Council to succeed the late Sir William Perkin as president of the Society.

ELECTROLYSIS AT LOW TEMPERATURES.

A paper by Dr. BERTRAM D. STEELE on "the electrolysis of salt solutions in liquefied sulphur dioxide at low temperatures" was read in abstract.

This is a preliminary account of the results at present arrived at in the course of a general study of the electrolysis of salts in liquefied gases. The present paper deals with the case of a solution of potassium iodide in sulphur dioxide. Electrodes of various materials were used, and the changes at anode and cathode were carefully studied. With platinum or mercury cathodes a very rapid diminution of current (depending on the initial current density), due, in the author's opinion, to a film of sulphur, was observed. Potassium sulphite with an admixture of sulphur was after continued electrolysis found to be deposited on these cathodes. Using silver, copper, or iron cathodes of large area, a constant current was maintained, the sulphides being formed in these cases. Iodine was formed at the anode, being either liberated or found in combination, depending on the metal employed. No potassium as metal was found to be deposited on the cathode. The author concludes that sulphur cations exist in the solution.

Measurements of conductivity and ionic velocities have also been made, and the results obtained will be published in due course.

In the discussion which followed Dr. T. M. Lowry expressed his doubts as to the existence of sulphur ions. He thought secondary reactions would explain Dr. Steele's observations.

REDUCTION OF BORIC ANHYDRIDE AND SILICA BY ALUMINIUM.

A paper by Messrs. F. F. WESTON and H. RUSSELL ELLIS on "the action of aluminium powder on silica and boric anhydride" was read in abstract by Mr. Weston, who showed on a small scale, some of the reductions described.

The authors have studied the action of aluminium powder upon boric anhydride and silica respectively. It is shown that in the case of boric anhydride the reducing action of the aluminium depends upon the fineness of both the aluminium and the boric anhydride, *e. g.*:

(*a*) Mixtures in molecular proportions of the finest obtainable aluminium powder and powdered B_2O_3 which has passed through a sieve of 14,400 meshes to the square inch react at once, in the cold, when started with a fuse of Mg ribbon and BaO_2 powder.

(*b*) Mixtures in proportion of Al_2 to $2B_2O_3$ only react when heated to dull redness in a muffle furnace.

(*c*) Similar mixtures to (*a*) and (*b*), but using B_2O_3 that has only passed through a sieve of 3,600 meshes to the square inch, only react when heated to 300° C. and dull redness respectively.

The products of the reaction were shown to be Al_2O_3 and mixtures of boron with aluminium borides, the latter predominating in the mixture containing molecular proportions and the former in the other mixture.

In the action of aluminium upon silica the authors used for the latter kieselguhr, precipitated silica, and fine silver sand. Here again the action took place more readily with the finer varieties of silica, the speed and energy of the reaction being in the order—precipitated silica, kieselguhr, silver sand.

The action took place in the cold with precipitated silica and kieselguhr on being started with a fuse of Mg and BaO_2, when the constituents in the mixture were in the ratio of $3SiO_2$ to 8Al; when the mixture contained the constituents in the ratio of $3SiO_2$ to 4Al the reaction only took place on heating the mixture to dull redness. When sand was used the mixture had to be heated to a dull redness in each case before the action commenced, and in the mixture containing $3SiO_2$ to 4Al free sand and free Al were found in the product.

The products of the reaction contained in all cases Al_2O_3, silicon (as shown by the production of $SiCl_4$), and probably some silicides of Al.

In the discussion which followed, Dr. R. Seligman suggested that some of the heat required in these reactions was furnished by the aluminium or boron, as the case may be, burning in air. The fireproof slags obtained in many cases were being used for making acid-resisting crucibles and for other industrial purposes. Dr. F. M. Perkin pointed out that the difficulty of getting a fusible slag in all cases prevented the preparation in a pure state of products like boron and silicon.

Calcium Hydride as Reducing Agent.

Dr. F. M. Perkin and Mr. L. Pratt read a paper on "the reduction of metallic oxides with calcium hydride" and illustrated some of the reductions.

Various metals can be reduced from their oxides and in some cases from their chlorides. A particularly vigorous reaction takes place with a mixture of metallic calcium and wolframite. The tungsten is melted and is obtained on cooling as a hard regulus. A fuller abstract of this paper will be given in our next issue.

CORRESPONDENCE

Presidency of the American Electrochemical Society.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—The very flourishing and progressive condition of this young giant among our national societies, makes the proper selection of a head for its next year a matter of importance. It is a question which the members of this society should decide with care, not taking simply the man most available, or the man most willing to wear the honor, but the man who by reputation, temperament and ability is best fitted to lead the society and to contribute most to its advancement.

The first, second and third presidents of the society were university professors, who gave the best they had to give to the benefit of the society; the fourth president was a consulting electrical engineer of prominence, whose labors and name lent prestige to the office; the present president is one of the most practical and industrious professors of electrochemistry to be found inside the walls of an American university. One class, however, has been conspicuous for its absence from this roll of honor—the pioneers of industrial electrochemistry. Has not the industry itself a man of sufficient prominence and ability to be worthy the honor of the presidential chair?

To be of the greatest use to everybody concerned, the society should, in its officers, policy and activities, represent the scholastic, the laboratory or experimental, and the utilitarian or industrial sides of electrochemistry. On that we are all agreed; and it can be fairly said that the society has been very creditably living up to those ideals.

It would seem now, however, that the time has arrived, at the present stage of the society's development, when the best interests of the society call for a man prominent in the electrochemical industry to step into the presidential chair, and thus to neutralize the suspicion which may prevail in some directions that the society (as represented by the majority of its presidents) has a leaning towards the academic and theoretic side of electrochemistry.

It is absolutely true that such a suspicion is not borne out by the facts, that a perusal of the *Transactions* will show as many eminently practical papers from practical men as of theoretical papers from college professors.

But is it not best to once for all meet such an attitude of mind by removing the only pretext for its existence, that is, by putting a pioneer of the electrochemical industry into the presidential chair?

Among the many investigators, developers of industries, representatives of applied electrochemistry as it exists in America, it is not easy to select the man who should thus most suitably represent the society.

However, among them is one whose labors in supplying electrochemists of all classes and in all countries with indestructible electrodes, have placed him in a class by himself, the most cosmopolitan and most representative of American electrochemical industry—Mr. Edward G. Acheson.

In electing Mr. Acheson as its president, the American Electrochemical Society will honor one who has done not only splendid work in the development of the carborundum and graphite industries, but whose work in the artificial graphite industry has really and materially assisted the development of probably half of all the electrochemical industries now in operation.

The blanks asking members of this society to nominate a president for the forthcoming year are now in their hands, and it is our earnest hope that the society will nominate the one man who, at this juncture, would most fittingly meet the needs of the position, fill the qualifications for the honor, and give international prestige to the society.

Charles F. Chandler.
Charles M. Hall.
Samuel A. Tucker.

New York and Niagara Falls.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—I heartily approve the nomination of Mr. E. G. Acheson for the presidency of the American Electrochemical Society. I have expressed this opinion annually for a number of years. Carl Hering.

Philadelphia.

Nitric Acid From Air.

Among the workers in the field of the fixation of atmospheric nitrogen by electric discharges, the names of I. Moscicki and I. von Kowalski, in Freiburg, in Switzerland, have been noticed repeatedly in this journal. An interesting summary of their work has now been given by Mr. I. Moscicki himself in recent issues of the *Elektrotechnische Zeitschrift* Oct. 17, 24 and 31), from which the following account is taken.

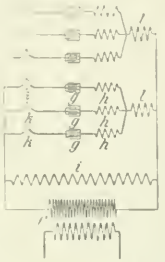


FIG. 1. — CONNECTIONS FOR PRODUCING HIGH-FREQUENCY DISCHARGES.

Mosciciki's first experiments with high-voltage, high-frequency discharges were made in 1900 in Prof. Kowalski's physical laboratory at the University of Freiberg. Among the results obtained at that time were the observations that saturation of the air with steam did not improve the efficiency essentially, while enriching the air with oxygen (so that the gas mixture contained equal quantities of oxygen and nitrogen) increased the yield by 20 per cent. The "Initiativkommittee für die Herstellung von stickstoffhaltigen Produkten" was then founded in 1901, to reduce the process to a commercial scale.

The arrangement first used is indicated in Fig. 1, 50,000-volt alternating current of ordinary commercial frequency being supplied to the system of condensers and inductance coils; *k* are the air gaps, *g* condensers, *h* small inductance coils, *l*

FIG. 2.—ELECTRIC FURNACE WITH CONDENSERS AND INDUCTANCE COILS.

larger inductance coils. The frequency of the discharges passing through the air gaps was 6,000 to 10,000 periods per second. The large inductance coil *i* served to compensate the phase difference. A special plant was erected to make the high-tension condensers. In these experiments the following facts were established:

The further oxidation of NO to NO_2 requires a comparatively long time. With a proper arrangement of the absorption towers it is possible to absorb very dilute gases. A 60 per cent concentration of pure nitric acid in water, free from nitrous acid, may be obtained by absorbing the gases in water heated to 60° C. By adding 5 per cent of a mixture of hydrogen and oxygen (detonating gas) to air it is possible to increase the yield by 20 per cent.

In 1903 a 100-hp. plant was erected in Vevey, Switzerland. A 75-kw. transformer raised the voltage from 3,600 to 50,000, the frequency being 50. The electric furnace was an iron tower of 4.6 meters height and 1.5 meters diameter. One electrode, which was common to all flames, consisted of an aluminium axle in the center of the tower, from which points projected at regular intervals. Opposite to these points the other electrodes were provided, projecting through the walls. The distance between the electrodes was 10 centimeters. The air was introduced into the tower at the bottom, and the treated air passing out from the top was led to the absorption towers.

Fig. 2 shows the furnace in the center with the sets of condensers and inductance coils placed around the furnace. The transformer is shown at the left-hand in the front. Instead of the electrical connections of Fig. 1 those of Fig. 3 were used. The numerous inductance coils *l* of Fig. 1 are omitted and replaced by two inductance coils s_1 and s_2. The two condensers C_1 and C_2 are connected at one end to the feeders and at the other end to earth. The common electrode in the center is also earthed. With this arrangement the required insulation is reduced from 50,000 to 25,000 volts.

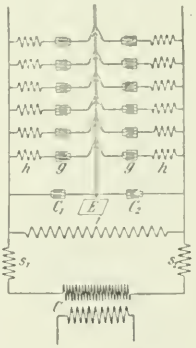


FIG. 3. — MODIFICATION OF THE ARRANGEMENT OF FIG. 1.

Fig. 4 shows the arrangement of the chemical plant. The gases coming from the furnace pass through six absorption towers. In the first two towers A and A_1 hollow balls of acid-proof stoneware are used as filling material. The next two towers B and B_1 are filled with plates according to the system of Lunge. In the last two towers C and C_1 filling material of Kypke is used.

The circulation of the gas is accomplished by means of the stoneware exhauster D, which sucks the gases from the furnace into the first tower and drives them through the following towers.

The first four absorption towers A, A_1, B, B_1 have a common reservoir with a montejus F, which raises the liquid into two upper distributing reservoirs which are connected together. By means of valves the flow of liquid to each of the four towers is regulated.

The fifth tower C has its own collecting reservoir with a montejus F, which raises the liquid into the reservoir E. This has a capacity of 600 liters and is placed at the top of the whole works. The sixth tower has its own collecting reservoir, montejus and distributing reservoir.

The gases mixed with air pass into the first tower A. The amount of liquid is limited, the temperature of the outflowing liquid is 50° C. Under these conditions nitric acid alone is formed. Any nitrous acid decomposes at once, and the escaping nitric oxide is oxidized by the oxygen of the air (with which the gases are mixed) to NO_2. This is absorbed in the next tower in which cold water is used.

In order to cool the warm gases which escape from the first tower and in order to wet them well, a spray apparatus H is provided between the first tower and the exhauster, so that the gases are intimately mixed with liquid taken from the upper distributing pipes.

In the second, third and fourth tower the same liquid is used

as in the first. But in these three towers it is cold and more liquid is employed than in the first tower where it is warm. The largest part of nitrogen oxides is absorbed in these four towers.

In the fifth tower the quantity of liquid used is as much as in the first four towers together. This results in a much lower concentration in the fifth tower and in a much more energetic absorption of any rests of nitrogen oxide.

As long as the concentration of the acid in the first four towers is not sufficiently strong, the outflow of the first tower

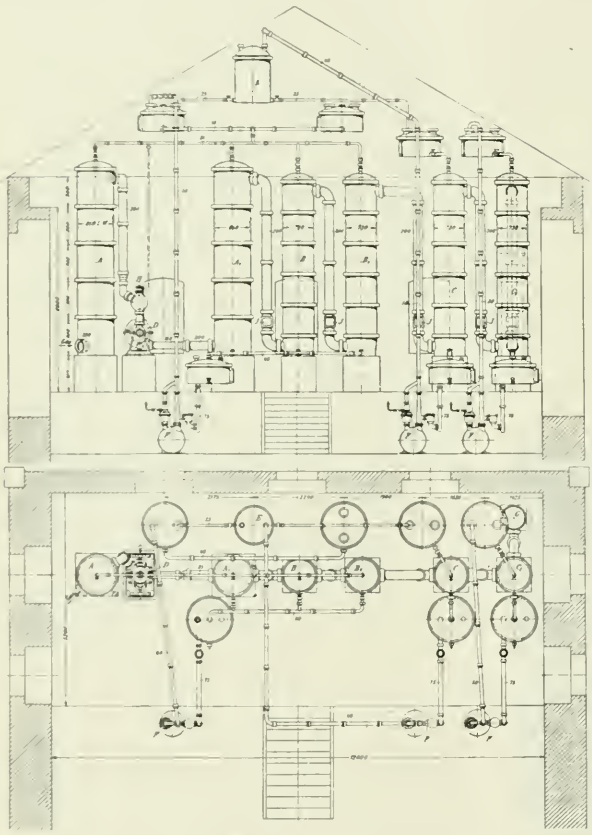


FIG. 4.—ARRANGEMENT OF ABSORPTION TOWERS.

is connected with the common collecting reservoir. By the constant heating of always fresh parts of the liquid its content of nitrous acid is maintained low. When the concentration has been brought up to the desired percentage, the valve between the first tower and the collecting reservoir is closed and the acid is slowly taken from the first tower through a special outflow. Since it is warm it is absolutely free from nitrous acid.

After the greatest part of the concentrated acid of the first four towers has been removed, the less concentrated acid of the reservoir E of the fifth tower is introduced into the two distributing reservoirs of the first four towers to be further concentrated in the latter. A new quantity of water is introduced into the fourth tower.

Since part of the nitrous acid decomposes at ordinary room temperature, traces of nitrogen oxides remain in the gases. In order to absorb these, concentrated soda solution is used in the sixth tower, whereby chiefly sodium nitrite, $NaNO_2$ is formed.

The seventh tower G, which is much smaller, is filled with hollow balls, and no absorbing liquid is employed in it. Any liquid particles carried with the air from the sixth tower are here arrested. The escaping gases pass into the atmosphere.

This scheme failed for the following reasons. In the first place the cost of installation was pretty high. The many flames required considerable complicated and expensive electric apparatus. When it was attempted to increase the energy in each flame it was found that the yield was diminished. Moscicki, therefore, decided to entirely give up the high-frequency experiments and to proceed with an entirely different system.

* * * * * *

In the new system of Moscicki the magnetic deflection of an arc is used. This is also employed in the well-known system of Birkeland and Eyde, but the method is a different one.

The study of a quiet flame shows different zones within the flame. Only the hottest zone, however, is useful for oxidation of the nitrogen. Within this hottest zone a maximum amount of nitrogen oxide is produced, which, when coming into the cooler zones is again decomposed. It is, therefore, important to suppress the cooler zones. This is accomplished by magnetic deflection of the flame. The magnetic flux only sets those parts of the flame into motion which carry the electric current, while, on account of the rapid moving, the less hot zones are completely suppressed.

The method employed by Moscicki is very simple and is based on the use of two concentric ring electrodes (Fig. 5). The arc passes from one ring E_1 to the other E_2 in radial direction. A magnetic flux is provided perpendicular to the plane of the drawing. The arc is thereby deflected and revolves continuously around in the annular space between the two rings. The revolving arc gives the appearance of a luminous ring between the two ring electrodes.

FIG. 5. REVOLVING FLAME.

On the basis of this principle the furnace shown in Fig. 6 is constructed. The arc plays between the copper cylinder *a* and the copper rod *b*. In order to keep the arc at the lower end of *b* a projection *k* is provided on the inner surface of the cylinder *a*.

The copper rod *b* is hollow for the sake of water cooling. The external diameter of this copper rod is 6 centimeters. The internal diameter of the copper cylinder *a* is 15 centimeters, so that the distance between the two copper surfaces is 45 millimeters. However, the distance between the projection *k* and the lower end of the copper rod *b* is only 15 millimeters; *c* is of porcelain, to insulate the inner copper cylinder from the outer one. The gases are introduced through *c* and flow in the direction of the arrows, leaving the furnace into the refractory clay pipe *g*.

The magnet coil *h* produces the magnetic field, and the outer copper cylinder *a* as well as the magnet coil are insulated by means of oil filled into the reservoir *m*. The oil is kept cool by means of the water circulation *i*.

The experiments were first made with alternating current of 50 periods. With an air gap of 15 millimeters at the place of the arc a voltage of 3000 was required.

To light the arc the arrangement, illustrated in Fig. 7, was developed by Mr. Moscicki. The arc F plays between the electrodes E and E_1. The alternating-current supply circuit A, B is connected directly to the two electrodes E and E_1, and also to the primary of a transformer T, which permits raising

the voltage to, say, ten times the normal value. S, L and D are inductance coils, K condensers, *f* a spark gap. The transformer T supplies to the two conductors *a* alternating current of normal frequency, which discharges through the spark gap *f*, and thus produces high-frequency alternating current, which then bridges the gap F so that the arc is lighted.

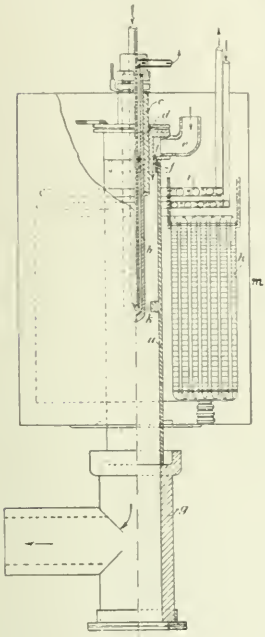


FIG. 6.—REVOLVING-FLAME ELECTRIC FURNACE.

Tests lasting from 1 to 4 hours under different conditions and consuming from 12 to 27 kw gave as the concordant result a yield of at least 60 grams HNO_3 per kilowatt-hour, for this small furnace and the comparatively small energy quantities employed. It was found that with higher speed of the air in the flame the yield was increased.

The above figure is equivalent to 525 kg. HNO_3 per kilowatt-year. This is considered to be the minimum and might be guaranteed. The experience of the author seems to prove, however, that for the dimensions of the furnace employed a much greater amount of energy should be consumed in the flame. With a corresponding increase of the amount of air treated and with a much higher speed of the air better results are expected.

While this furnace can be used with alternating current it is particularly adapted to direct-current operation. Preliminary tests with direct current have shown that a supply pressure of 1,500 volts is sufficient. In this case the flame revolves continuously in one direction and the speed of the rotation is absolutely uniform, as is the energy consumed per unit of time. With alternating current the energy in the flame pulsates, but this is not the case with direct-current operation. The use of direct current has the further advantage that no auxiliary appliances besides the magnet winding are required.

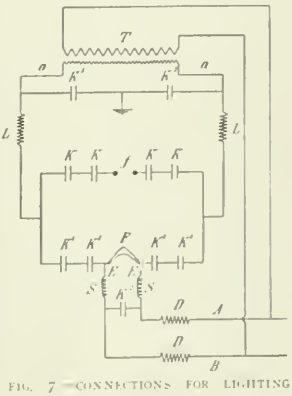


FIG. 7.—CONNECTIONS FOR LIGHTING THE ARC

The furnace is connected directly to the terminals of the generator, but under such conditions that the direct-current dynamo supplies only a single furnace, or if several furnaces are fed they must be connected in series. The dynamo must be provided with a compound winding, which counteracts the shunt winding and prevents the current from rising beyond a permissible maximum value. Ninety-nine per cent of the total energy at the terminals of the furnace are consumed in the flame itself, since the magnet coil, which is the only auxiliary apparatus, consumes scarcely 1 per cent of the total energy in the case of a 500-kw. furnace. It is further believed that the furnace will be well suitable for treating air under pressure. Since the results so far obtained are quite satisfactory they are to be continued on a larger scale.

* * * *

FIG. 8.—REVOLVING FLAME.

At the recent seventy-ninth Versammlung Deutscher Naturforscher und Ärzte, in Dresden, an interesting paper on the same subject was presented by Dr. BRION. The paper may be found in full in *Physikalische Zeitschrift*, Oct. 24. As a matter of fact, he described luminous-ring experiments in which an arrangement was used by him and Dr. Mahlke, which is practically identical with that of Moscicki. It is also mentioned that an analogous patent specification by Pedersen exists (German patent 183,-041).

Fig. 8 shows a disc A and a concentric ring B which are in the same horizontal plane and form the two electrodes. A magnetic field is produced perpendicular to the plane of the arc. It is produced preferably by means of a coil, which is fed with the same current which produces the arc, so that in the case of alternating current the variations of the field strength are in phase with those of the arc. The arc is forced to rotate, but does not remain straight, since near the periphery B the linear speed is greater than near the disc A. The arcs assume, therefore, a curved shape, as shown in the illustration. The experiment is stated to succeed equally well with direct current and alternating current.

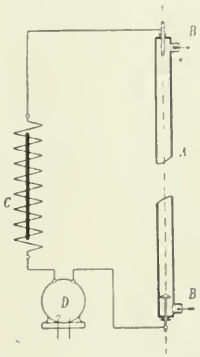


FIG. 9.—ARRANGEMENT OF BADISCHE ANILIN U. SODA FABRIK.

If the speed of rotation is large enough the experiment gives the impression of a uniformly luminous ring. The author doubts, however, whether the whole ring participates uniformly in the passage of the current. It is more probable that certain distinct paths only act as carriers of the current. It is improbable that in this luminous ring or in the Birkeland-Eyde luminous disc the temperature is as high as in a strong, quiet arc. In the latter it is about 4,000 absolute temperature. Birkeland assumes the temperature of his flame disc to be 3,200° C. From Brion's experiments it might be estimated that his luminous ring has a temperature of 2,700° C. in the average.

The yield was found by Dr. Brion to be practically the same with direct current and with alternating current and to increase greatly with the length of the arc. In his experiments in which 3 to 5 kw. were employed, the yield was not greatly different from Birkeland's result, namely, 400 to 500 kg. of HNO_3 per kilowatt-year, with a concentration of 1 to 1.5 per cent in the gases.

Finally another arc system may be mentioned, that of the Badische Anilin und Sodafabrik. It is based on the fact that a quiet, continuous arc of several meters length may be produced if enclosed within a tube of suitable diameter. The principle is indicated in Fig. 9, where D is the dynamo, A the tube in which the arc is produced between the electrodes B and B, while C is an inductance coil. The arrows indicate

the flow of the air, which is pressed into the tube at the bottom. It is stated that it is possible to consume several hundred kilowatts continuously within a single tube. While nothing is known on the details of construction of the apparatus, it is reported that the yield of nitric acid as well as the concentration of the gases is somewhat higher than in the Birkeland-Eyde process.

Vanadium.

Mr. J. Kent Smith, who has long made a specialty of vanadium and vanadium steel, presented a paper on "The Present Source and Uses of Vanadium," at the Toronto meeting of the American Institute of Mining Engineers. The paper is printed in full in No. 17 (September) of the *Bi-Monthly Bulletin* of the institute.

Mr Smith also introduced a discussion on vanadium steel at a recent meeting of the Engineers' Society of Western Pennsylvania. This discussion is printed in full in the October issue of *Proceedings* of the society.

In his American Institute paper Mr. Smith first refers to the opening up of a large deposit of vanadium sulphide ore in Peru, South America. The mine is owned by the American Vanadium Co., of Pittsburg, Pa. The ore contains 40 per cent of vanadium sulphide, 31 free sulphur, 14 silica, 4 iron sulphide, besides nickel sulphide, molybdenum sulphide, alumina, lime, etc. Being a free-burning ore it is calcined with ease, losing 45 per cent of its weight in the process.

The calcined ore has the following analysis:

	Per Cent.
Vanadic oxide V_2O_5	58.08
Iron oxide	4.98
Molybdenum oxide	2.62
Nickel oxide	2.24
Silica	25.00
Alumina	4.52
Lime, magnesia, potash, soda, etc.	2.56
Sulphur	0.23

Vanadium is a silvery white metal of high melting point—said to be 2,000° C., and, at all events, higher than the melting point of platinum—so that its commercial use in the metallic form is practically restricted to its use as a refractory metal (in the filaments of electric lamps, for instance). An alloy of iron with vanadium in the proportion of two parts of iron to one part of vanadium has a melting point of 1,375° C., or more than 100° C. below that of mild steel; and it is in this form that the metal is marketed for the use of the steel maker.

The old custom of judging a steel by its resistance to static load, and the amount it would stretch under such load, gave a certain general guide as to the behavior of metal under conditions of engineering practice which are now rapidly being left behind. Even under these conditions, mysterious failures occasionally occurred, which, it is now evident, had their origin in the inability of the metal to resist strains applied in a totally different manner from that in which it was tested.

As the requirements of modern engineering construction became more and more drastic respecting the power of resistance to rapidly repeated strains and shocks, accompanied, of course, by increased demands as to actual strength, the old test conditions were still further receded from in practice; and it became necessary to resort to alloy-steels.

"Here some success was scored; but the true requirements were nevertheless lost sight of, and the metal was still judged almost entirely by its behavior under static loads. With the same ductility, an increase in the strength was looked upon as the one desirable thing, although it is now recognized that this improvement in strength, if attained at the expense of dynamic properties in the original steel, is, in most cases, of comparatively little use to the engineer. In short, we lost ourselves in straining after something which we did not want, and which we attained only at the expense of something we did want."

Since, in modern machine construction, and especially in those parts which are liable to repeated stresses, to alternating stresses, to simple, repeated or alternating impacts, and to fatigue (which is the outward and visible sign of intermolecular vibratory deterioration), a new field has been opened, and in this field vanadium has been found, by extended experiment and practical experience, to be uniquely valuable. As to static properties, vanadium intensifies greatly the strengthening effect of another ingredient, such as chromium, thus enabling the proportion of the latter to be so reduced as to avoid "poisoning" the metal with regard to desired dynamic qualities. Moreover, vanadium is itself highly contributory to the dynamic excellence of mild steel. By retarding segregation, it renders the metal particularly susceptible to enormous improvement by tempering and heat treatment generally. By virtue of this characteristic, steel can be "automatically" rendered highly resistant to wear and abrasion. Again vanadium toughens steel; confers upon it great power of resistance to torsional rupture; in a word, endows it with increased "life" in practical use.

Being a powerful "medicine," vanadium is used in small doses only. In engineering steels, the maximum proportion required seldom exceeds 0.2 per cent. By its judicious use, combinations are thus made possible which could not be formed without it, and which permit the successful fulfillment of complicated requirements, whether chiefly static, chiefly dynamic, or divided more or less equally between the two classes.

Table I.—Properties of Vanadium Steel Compared with Some Other Steels.

Test	For Comparison. 1. Carbon "Axle" Stock.	For Comparison. 2. Nickel "Axle" Stock.	Dynamic. 3. Vanadium Axle Steel	Combined. 4. Vanadium Crank-shaft Steel.	Static. 5. Vanadium Continual Mesh Gear Steel.	Nature.
Yield-point, pounds per square inch	41,330	42,270	63,570	110,100	224,000	Static.
Ultimate stress, pounds per square inch	65,840	87,360	96,080	127,800	232,750	Static.
Ratio	0.62	0.56	0.66	0.87	0.96	Static.
Contraction of area, per cent	61	58	61	58	39	Static.
Elongation, per cent on 2 inches	42	34	33	20	11	Static.
Tortional twists	2.6	3.2	4.2	2.5	1.8	Static.
Alternating bends	10	12	18	10	6	Intermediate.
Pendulum impact, foot pounds	12	14	16.5	12	6	Dynamic.
Alternating impact—number of stresses	960	800	2,700	1,850	800	Dynamic.
Falling weight on notched bar—number of blows	25	35	69	76	..	Dynamic.
Rotary vibrations—number of revolutions	6,200	10,000	67,500	..	..	Dynamic.

How these varying and partially contradictory demands are met by vanadium is shown in Table I., which contrasts the properties of vanadium steel with some other steels. The data presented in this table are stated by Mr. Smith to have been obtained under like conditions of testing.

In his address before the Engineers' Society of Western Pennsylvania, Mr. J. Kent Smith covered practically the same field so that we will notice only those points which are new. Mr. Smith referred to the fact that we talk about steels of a certain "complete analysis," but the so-called complete analysis is, after all, very incomplete. We do not reckon in it the estimation of elements which here are most dangerous. "There is no doubt one of the commonest of such is oxygen, a terribly mischievous thing in the wrong place. I firmly believe, that in fairly easy service many steels fail chiefly on account of their oxygen contents; for I have never yet found steel oxidized in the furnace to stand repeated strains as well as properly finished steel."

One of the beneficial effects of vanadium is that it deoxidizes steels. To remove all the oxygen by means of vanadium would, of course, be very expensive. The vanadium should only be used to reduce the last traces of the oxygen. Vanadium also removes nitrogen, and this is of equal importance.

Mr. Smith also gave some data on the use of vanadium steel for crankshafts, springs and rails. With regard to the rail question, he said that "the trouble is not, as some newspapers say, all due to the effect of piping, nor to the effect of rushing through over-crowded mills, nor is it due to initial brittleness; it is mainly due to the potential brittleness, and we must retard the development of this brittleness in order to arrive at the true solution of the problem. Other causes are certainly contributory, and no sane man will maintain that a segregated rail is as good as an unsegregated rail, or that it does not matter if the rail is piped. Eliminate the segregation, eliminate the piping, and we are two steps to the good, but we are not touching the real root of the difficulty. Vanadium is the certain cure here, and the increased wear of vanadium steel should so make up for the increased first cost as to lead us to gain in safety (or insurance) at little or no additional expense in the long run. An adequate discussion of this subject would occupy a very large amount of time."

In Swedish steels, Mr. Smith has found by numerous analyses a small content of vanadium (in the average 0.05 per cent), and he believes that it is this small amount of vanadium which gives to some Swedish irons their property of resisting vibrations, etc.

There was a very extended discussion in which Mr. C. C. Smith and Mr. R. A. McDonald confirmed many of the statements of Mr. J. Kent Smith, with respect to the good effect of vanadium.

Mr. C. C. Smith used vanadium steel for locomotive frames and had "no hesitancy in saying that the best heat of steel they have ever made was the one made of vanadium." He has also made various tests, among them the following:

"This (showing samples) was a rather severe test. I took two pieces of steel 1 inch by ½ inch and bent them to an angle of about 90°. I then straightened them out and bent them the other way to about 90° and then back again, etc. That was a more severe test than I had intended. I only intended them to be straightened and bent back the same way. Our ordinary steel bent twice to 90°, and the third time to about 75° when it broke. The vanadium steel bent four times to 90°, and broke at 90° on the fourth bend. It showed, perhaps, 30 per cent better bend than our ordinary steel."

The tensile strength and elastic limit were both increased materially, and the reduction and elongation were reduced in the vanadium steel in comparison with their ordinary steel. "This indicates these bending tests mean that vanadium represents more even than my reports show. We can get practically the same elongation and reduction with 82,000 pounds tensile strength carbon steel, but we cannot get as high an elastic limit in 82,000 tensile strength carbon steel, and it would not give anything like the bending results we got from the vanadium steel."

The question of cost was then brought up and Mr. J. Kent Smith stated that the cost of vanadium alloy is $5.00 per pound of vanadium content, and that it must be taken into consideration that the maximum quantity of vanadium necessary to be used is about 0.20 to 0.25 per cent.

Mr. F. N. Speller remarked that it is pretty safe to assume that we do not get any vanadium content in steel until all the oxygen has been satisfied. How far is vanadium responsible for the rather remarkable dynamic properties we get in vanadium steel, and how much of this is due to the more thorough deoxidization which we perhaps never got before?

Mr. J. Kent Smith replied that it is perfectly feasible to finish an ordinary open-hearth heat so that it is practically free from oxygen, and when adding vanadium, about 90 per cent of it will be actually added to the steel. To the question of Mr. Speller whether one has to use two ladles there, Mr. Smith replied: "No, you can do it perfectly in the one ladle. Certainly, in my practice in Europe I used two ladles in order to thoroughly deoxidize the steel in the first ladle, as I found that the increased economy and regularity obtained more than paid for the extra trouble in the lining of the second ladle. One should deoxidize the steel very thoroughly before adding the vanadium, and it is easily feasible to so deoxidize in the furnace. Of course, if we add the manganese in the furnace, we have to look for a greater manganese loss. Where I use two ladles I do all the deoxidizing in the first ladle, then teem through a large nozzle into the second ladle. It is most practicable to do this where one is dealing with large sized casts, as you have no heat reserve to warrant using two ladles when you have only two or three tons. With a 15 or 20-ton cast, it is practically easily possible to use two ladles, tapping very hot into the first ladle and seeing to it that the nozzle and stopper of the first ladle are big enough."

Mr. Alfred Sang brought up the use of vanadium steel for rivets and bolts, especially for automobiles where there is a good deal of shock. Mr. Smith replied that for rivets, vanadium steel has proven very useful in practical work. The addition of vanadium to ordinary pure dead, mild steel, practically produces something akin to Swedish steel, and it is well known that Swedish steel is much better for rivets than is ordinary open-hearth steel. Mr. R. A. McDonald remarked that he had never found any vanadium in Swedish iron, but Mr. Smith thought this was due to the brands used by him. "We used a good many thousand tons a year of mild Swedish steel, and the average vanadium in it was 0.05 per cent."

Technical Analysis of Vanadate of Iron.

By Arden M. Wilson.

The determinations ordinarily required for each sample are vanadium, iron, silica and loss on ignition.

Vanadium, iron and silica are determined with one weighing as follows:

Place 3 gram of finely powdered vanadate in an 8-ounce Erlenmeyer flask and evaporate on the sandbath to dryness with 40 c. c dilute HCl (1-3). Take up with 10 c. c. concentrated HCl and heat to boiling. Dilute with 30 c. c. hot water, heat to boiling for several minutes and filter out the silica, letting the filtrate run into a small Erlenmeyer. Ignite and weigh SiO_2 as usual. The purity of the silica may be tested if desired by evaporation with HF and a few drops of H_2SO_4, the true silica being obtained by loss in weight.

To the filtrate from silica add 4 c. c. conc. H_2SO_4 and evaporate to white fumes. Cool and add 30 c. c. cold water and boil until everything is in solution. Transfer to a tall

narrow beaker with a small amount of hot water so as to keep the volume of the solution about 40 c. c. Heat to boiling and add H_2O_2 (3 per cent solution) until a permanent dark red color is obtained, then cover the beaker with a watch-glass and add carefully concentrated caustic soda solution until all iron is precipitated. (The precipitate should be reddish in color. If dark brown or greenish, more H_2O_2 must be added.) Boil for several minutes, then dilute to about 200 c. c. with hot water and heat to boiling. Let settle a few minutes and filter rapidly, allowing the filtrate to run into a 600 c. c. Erlenmeyer.

Wash thoroughly with boiling water, cleaning out the flask carefully so as to get all the ferric hydroxide on the filter. The filtrate should be clear and colorless; a yellow color usually indicates a trace of iron. Cool the filtrate somewhat and add conc. H_2SO_4 until a decided acid reaction is obtained upon testing with litmus. Heat to boiling and reduce the vanadium with excess of strong SO_2 water. Now boil off the excess SO_2 while passing CO_2 gas through the solution. Titrate with potassium permanganate until a pink color is obtained that does not fade when the solution is brought to a boil. Again reduce the boiling solution, which should be about 400 c. c. in volume, being very careful to add sufficient SO_2 water so that a strong odor is obtained after shaking. Boil off excess SO_2 and titrate hot with permanganate to the first pink color permanent after thorough stirring. The end-point by this double reduction is sharp, but the pink color will fade in a few minutes. This slow fading of the color may be disregarded, as the first persistent pink tinge is the true end point.

The precipitated iron is dissolved on the filter with hot dilute H_2SO_4 (1:5), allowing the filtrate to run into an 8-ounce Erlenmeyer. About 30 c. c. of the dilute acid will be required, and a large excess should be avoided. Add 10 c. c. conc. HCl and 3-5 grams of granulated zinc, and allow to stand until colorless, then add about 25 c. c. cold water and 10 c. c. conc. H_2SO_4 to dissolve excess of zinc. When all zinc is dissolved, fill flask with cold water, shake and filter through a cotton plug, letting the filtrate run into a large beaker. Wash well with cold water and make up bulk of solution equal to that used in standardizing the permanganate and titrate at once for iron.

The separation of iron and vanadium by means of caustic soda is ordinarily complete in one precipitation, but the precipitate of ferric hydroxide is usually tested for vanadium by adding H_2O_2 to a little of the sulphuric acid solution of the iron. If a red color is obtained, the precipitation is repeated and the filtrate added to that obtained from the first precipitation.

The filtrate from the iron may be tested by acidifying a few drops with HNO_3 on a spot-plate and adding KSCN, a red color indicates iron. A very slight reddish tinge may be disregarded, as it indicates only a trace of iron, but if a strong test is obtained the analysis should be rejected. The color of the filtrate from the precipitated iron is usually taken to indicate whether or not iron is present in quantity sufficient to materially affect the results. A colorless filtrate ordinarily means a complete separation.

The loss in weight upon igniting a sample of vanadate of iron is due chiefly to the giving off of moisture and free chlorine.

Take 1 gram and place in a small porcelain crucible.

Heat carefully at first; then at a strong heat until no more chlorine is evolved. This may be determined by means of a strip of filter paper which has been dipped in a solution of KI and starch. As long as chlorine is given off it will color the paper blue. Finally, cool in a desiccator, weigh and calculate percentage loss in weight.

Vanadium Alloys Co.,
Newmire, Col.

Metallurgical Calculations.

By Jos. W. Richards, Ph. D.
Professor of Metallurgy in Lehigh University.

Electric Smelting of Copper Ores.

The use of electrothermal processes for smelting copper ores has been proposed in recent years, and in a few cases experimentally tested. The whole question depends on the recognition and appreciation of a few fundamental facts. By far the great bulk of all copper ores are sulphide ores, and in many cases the sulphur and iron present are sufficient heat producers to allow of the smelting of the ore simply by the heat of their oxidation, if the operation is skillfully conducted. Such is the basic principle of pyritic smelting, and whenever it can be applied it is very economical to do so, and electric processes have no chance of an application.

Other ores of copper contain so small an amount of the metal that the result of the smelting down of the whole to a fluid mass, by any method of fusion, would not repay the cost of the operation. Some such ores can be treated by aqueous and other methods not involving fusion, with a margin of profit to pay for the operation.

The only field for electrothermic processes appears to be in the smelting down of ores carrying too little sulphur to be "pyritically" smelted, and which require, as usually treated, the use of carbonaceous fuel to assist the fusion. Wherever such fuel is expensive, and electric power may be obtained at a low price, an electrothermic process might be theoretically possible and profitable.

Such conditions may easily occur in the vicinity of copper mines. Situated frequently among the mountains, remote from railways and cheap fuel, they frequently are near large water powers which would furnish cheap electric power. Some may be even so situated that concentration of a very lean sulphide ore to matte by use of fuel, or by mechanical concentration, would be unprofitable, and yet a concentration or simple melting to matte by electrically-generated heat be profitable.

There are, so far as the writer knows, no electrothermal processes yet in commercial operation on copper ores, yet they have been tested experimentally with promising results. Vattier, for instance, conducted experiments at the Livet works of the Compagnie Electrothermique Keller et Leleux, on April 23, 1903, in the presence of several distinguished metallurgists, such as Mr. Stead, of Middlesborough, Mr. Allen, of Sheffield, and Mr. Saladin, of the Creusot works. The ores were Chilian ores sent by the Chilian Government to test the possibility of electric smelting, taken from the "Vulcan" mine, owned by G. Denoso, and low-grade ore from Santiago. At the mines, coke costs $20 per ton, but the slopes of the Andes afford a fine opportunity for developing large water powers cheaply; it is estimated that the total cost of electric power delivered should not exceed $6 per kilowatt-year. A detailed account of these tests can be found in the appendix to the Report of the Canadian Commission on Electric Smelting, 1904.

Problem 121.

Vattier mixed his rich and poor Chilean ores to a charge consisting of

	Per Cent.
Copper	5.10
Sulphur	4.13
Iron	28.50
Manganese	7.64
Silica	23.70
Alumina	4.00
Carbonic acid	4.31
Lime	7.30
Magnesia	0.33
Phosphorus	0.05

This was charged directly into a shaft furnace 1.8 meters long, 0.9 meter wide and 0.9 meter high. The melted materials ran out into a forehearth 1.2 meters long, 0.6 meter wide and 0.6 meter high. Two carbon electrodes, 30 centimeters square by 170 centimeters long, were used in the smelting chamber, and two electrodes, 25 centimeters square by 100 centimeters long, were put in the forehearth to reheat it for tapping.

The matte obtained analyzed:

	Per Cent
Silica	0.80
Alumina	0.50
Iron	24.30
Manganese	1.40
Sulphur	22.90
Copper	47.90

The slag contained:

Silica	27.20
Alumina	5.20
Lime	9.90
Magnesia	0.39
Iron	32.50
Manganese	8.23
Sulphur	0.57
Phosphorus	0.06
Copper	0.10

The current used was 4,750 amperes at 119 volts; power factor = 0.9; 8,000 kilograms of ore mixture were smelted in 8 hours; consumption of electrodes 50 kilograms.

Required:

(1) A balance sheet of materials entering and leaving the furnace per hour.

(2) A balance sheet of the heat development and distribution in the furnace.

(3) The saving in cost of treatment per ton of ore, assuming electrodes to cost 4 cents per kilogram, coke $20 per metric ton, and that when coke is used one-third of its calorific power leaves the furnace in the escaping hot gases. Assume all other costs similar, except that air blast costs $0.10 per ton of ore smelted additional. Electric power $6 per kilowatt-year.

(4) If the resulting slag were smelted electrically for ferro-silicon, at an expenditure of 0.75 electric horsepower-year per ton of ferro-silicon obtained, and other smelting costs were $10 per ton, how much ferro-silicon would be obtained per ton of copper ore treated, and what would be its cost?

Solution:

(1) Balance sheet per 1,000 kg. of ore.

	Charges.	*Matte*	*Slag.*	*Gases.*
Ore: 1,000 kg.				
Silica	237 kg.	1	236	.
Alumina	40 "	0.5	39.5	.
Iron	285 "	25	260	.
Manganese	76 "	1.5	74.5	.
Sulphur	41 "	24	5	12
Copper	51 "	50	1	.
Carbonic acid.	43 "	...	.	43
Lime	73 "	...	73	.
Magnesia	3 "	..	3	.
Oxygen	137 "	2	74	61
Electrode:				
Carbon	6 "	..	.	6
	104	796		122

Composition of Slag.

	Calculated	*Analyzed*
Silica	29.5 per cent.	27.2 per cent.
Alumina	5.0 "	5.2 "
Lime	9.2 "	9.9 "
Iron	32.5 "	32.5 "
Manganese	9.3 "	8.2 "
Sulphur	0.6 "	0.6 "

Heat Development.

Electric energy per hour:

$4.750 \times 119 \times 0.9 = 509$ kilowatts.

$509 \times 860 = 437,750$ Cal. per hour

Oxidation of carbon.

$6 \times 4,300 = 25,800$ " "

463,550 " "

Heat Distribution.

Heat in matte:

$104 \times 270 = 28,080$ Calories.

Heat in slag:

$796 \times 400 = 318,400$ "

Heat in gases = 30,000 "

Loss by radiation and conduction = 87,070 "

463,550 " "

The radiation and conduction loss is 19 per cent of the total heat generated in the furnace—a satisfactory showing. The useful effect of the furnace is nearly 75 per cent, reckoning as usefully applied heat that contained as sensible heat in the melted matte and slag.

Nearly 90 per cent of this usefully applied heat is contained in the slag.

(3) If coke were used instead of electric heat enough coke would have to be used to furnish 433,550 Calories plus the heat in the gases. Since the latter is assumed to be one-third of its calorific power, the coke must have a calorific power of 650,325 Calories, which at 7,000 Calories per kilogram would require 93 kg. of coke per 1,000 of ore smelted. The costs of coke and blowing engine would therefore be

Coke,	$93 \times \$0.02 =$	$1.96
Engine,		0.10
	Sum	$2.06

The cost of electrodes and electric energy, which would replace coke and blowing engine, would be:

Electrodes,	$6 \text{ kg.} \times \frac{\$0.04}{6.00} =$	$0.24
Power,	$509 \text{ kw.} \times \frac{}{8,760} =$	0.35
	Sum	$0.59
	Saving	1.47

(4) The resulting slag contains, according to the balance sheet, 260 kg. of iron, 74.5 kg. of manganese, and 236 kg. of silica equal to 126 kg. of silicon.

It should produce, if completely reduced, 460 kg. of alloy (omitting the carbon it might contain) of the approximate composition:

Fe	260 kg. =	56 per cent.
Mn	74 kg. =	16 "
Si	126 kg. =	28 "
	460 kg.	

Cost of power $6.00 × ¾ × $0.75 = $3.37 per ton.

Other costs 10.00 "

Total costs per ton $13.37

This cost is very low, because of the very low figure assumed for power costs. However, the whole calculation points to the possibility of great savings in some localities in smelting down copper ores by electrically applied heat, and the possibility of cheaply producing at the same spot, valuable ferro-silicon as a by-product.

Physical Factors in the Metallurgical Reduction of Zinc Oxide.*

By Woolsey McA. Johnson.

Independently of the recognized chemical reactions involved in the production of metallic zinc, the process is affected by physical conditions in efficiency and by commercial as well as technical economy. To offer some observations concerning these conditions is the purpose of the present paper.

Among the important elements of this problem is the physical nature of the particles constituting the mass of zinc oxide to be reduced. This may be the result, either of the manner of the original deposition of the mineral, or of the treatment to which it has been subjected in the roasting furnace. The physical character of the reducing agent is another important factor, since the carbon of some coals is much more active in reduction than that of others. The degree of fineness, whether of ore or coal, or both, likewise plays a significant part. These factors, together with the physical admixture of foreign substances with the ore, may give rise also to chemical "side reactions," sometimes hindering or retarding and sometimes accelerating the reduction. Finally, thermal conditions, including the relative conductivity of the materials, deserve to be taken into account.

In firing a furnace with retorts charged with a mixture of roasted ore and coal, the first reaction is naturally the boiling off of the contained water; the next is the distillation of the light hydrocarbons from the coal; the next is the reduction of the iron oxide to protoxide and sub-oxide successively, and then to metallic sponge, and the final reaction is the reduction of the zinc oxide in the ore by the carbon to metallic zinc. This reaction commences at 1,022° to 1,060° C., according to the physical nature and condition of the coal and ore.

Since the retort and the charge are far from being good conductors of heat, we may assume that there exists in the charge a series of concentric hollow cylinders of gradually decreasing diameter, each hollow cylinder differing in temperature by a few degrees as the diameter grows smaller, the hottest part, of course, being the cylindrical layer next to the retort, and the coldest the core in the center of the charge. This is a convenient assumption for the purpose of illustration. In fact, such hollow cylinders do not exist separately, except as representing zones of temperature.

Now, with rapid firing, it is possible that the charge next to the retort walls may reach a temperature above that of the reduction of zinc, and, consequently, produce some zinc vapor, while in the center of the charge water is being boiled off. Obviously, this would be a bad way to fire the furnace, since the zinc-gas would be thereby so diluted that condensation would become practically impossible. The same evil thing occurs through the distillation of the hydrocarbons when too much light "gassy" coal is used. Diluting gas may similarly be formed from the reduction of the iron oxide when ores very high in iron are treated.

If we had an ideal charge, perfect in heat conductivity, it might be possible to keep all the contents of the retort at one temperature until the reaction requiring that temperature was complete; then immediately to elevate the temperature until the second reaction was complete, and so on, through the third and fourth reactions. This procedure would require, also, ideal conditions from a chemical standpoint, including a charge of such character that each of the several reactions would be practically complete at a temperature only three or four degrees above that at which it began. Such ideal theoretical conditions are beyond our reach, but may serve as a mental guide for formulating such conditions as are practically the best for any given situation as to ore and coal.

The firing of a zinc furnace for reducing ores high in iron should be done as follows: The furnace should be heated up to, and kept at, a temperature slightly below the reduction temperature of zinc, but as near that point as possible. This, in the course of an hour and a half or two hours will bring all the contents of the retorts to a uniform temperature of slightly below 1,020° C. Below this temperature the reduction of the iron oxide is largely completed. After this has been accomplished, the furnace should be fired for the reduction of zinc oxide.

If the reduction of the iron oxide and the reduction of the zinc oxide proceed simultaneously, the evolution of so much carbon monoxide and dioxide from the reduction of the iron oxide would sweep the zinc vapor through the condenser and burn it at the mouth. This is exactly what happens with too rapid firing. The bright, or so-called "angry" flame, burning the zinc with brilliant white fumes, while yielding practically no condensed metal, is the practical fact of which the above paragraphs are the explanation.

Through both special experiments and practical experience in zinc smelting I have found that the iron oxide has different degrees of reductivity, varying even more than that of zinc ores, according to the way they were originally deposited geologically and the way they have been roasted. This result corroborates the observations of Sir Lowthian Bell. A hard, dense zinc ore that is hard to roast, and gives a product not very porous, is naturally more difficult to reduce than one of a porous nature, which has been roasted at a low temperature. If, as sometimes happens, a zinc ore is roasted at such a temperature as to form an incipient slag, for example, an iron silicate, and also compounds of its different constituents, such as zinc ferrate, zinc silicate, zinc aluminate and lead silicate, the reduction of such an ore, so roasted, is retarded, its reductivity being decreased, because the compounds of zinc oxide are more difficult to break up than the oxide itself. Moreover, the particles are shrunk and cemented more closely together by the heat, just as a fire-brick, under the action of high heat, contracts and hardens, and their reductivity is thus decreased for physical reasons.

Thus it may be said that there are two kinds of work to be done in the reduction of zinc oxide. One is chemical work; the tearing of the atoms of zinc and oxygen away from each other against the force of affinity. The other is the work of tearing the molecules of zinc oxide from one another. This is physical work. Any agent that changes the aggregation of the molecules so as to make it denser increases the physical work to be done in reduction.

The formation of iron silicate in roasting is especially bad; for it is not easily reducible, and is itself a slag already formed, which will pick up other slag materials, and, collecting in the bottom of the charge, quickly cut a hole through the retort. For this reason several zinc plants in Kansas charge carbonates "green" into the retort, even though their bulk is greater.

Metallic iron as an iron sponge does not, in my opinion, have very deleterious effects, provided sufficient fine clean coal is present. In the first place, the iron seems to draw up in globules in the pores of the charge by capillary attraction, and to be held there as water is held by a sponge. Not only is its melting point high but it has no great chances to form alloys with other metals.

The iron sulphide, on the contrary, is really the most corrosive part of a charge, whether present in the charge as pyrites in the original coal or pyrites not roasted in the ore, or formed by the iron sponge acting on the zinc sulphide. At from 1,100° to 1,200° C. iron sulphide will dissolve fire-clay practically as hot water dissolves sugar. Several times, in my small electric crucible furnace, I have added pieces of a retort to molten iron sulphide, and observed a considerable evolution of sulphur dioxide, suggesting that an iron silicate formed. This product analyzes 3 or 4 per cent S and is partially a sulpho-silicate.

Moreover, molten iron sulphide is extremely mobile and will

* A paper read before the American Institute of Mining Engineers at the Toronto meeting. (Bi-monthly Bulletin No. 17.)

penetrate the pores of a retort, where it forms, under the oxidizing flames of the combustion gases, an iron slag, and cuts a hole through the retort. Then the metallic iron in the charge is oxidized and furnishes enough iron oxide for the formation of more slag. In the course of four or five days, if slagging has happened first on a retort in the top row, all the retorts vertically under the unfortunate one will be cut out and spoiled by the slag dropping down from it. The whole trouble is probably caused by an accidental and local excess of iron sulphide in one portion of the charge due to poor roasting or poor coal, or both, and an uneven "mix."

A phenomenon of zinc smelting which puzzled me for a long time is what is known as the "setting" of the furnace. When a furnace is fired up so rapidly at first that a great deal of zinc cannot be condensed but burns at the mouth of the condenser, the furnace-man will often suddenly reduce the temperature to stop this loss of zinc. If this change be too marked, the charge in the furnace becomes "set," and it is impossible to get the zinc out, even though the temperature be raised to a point much above that ordinarily employed. The reason is that a thick, heavy slag is thus formed, and, once formed, contracts on cooling, and encircles the particles of ore and coal. If the temperature had been brought up slowly the slag would never have been formed, or would have been formed only at the end of the shift, when the charge was "dry" of zinc.

This suggests another point. While a thick slag prevents reduction the formation of a very liquid slag facilitates it, probably by bringing the reacting substances into igneous solution, so that they can act on each other. In American zinc practice it is deemed inadvisable to form slag at any time if it be possible to prevent it, but in Europe, occasionally, the residues are tapped from the retorts as a liquid slag.

This brings us to the essential difference between European and American zinc furnace practice. By a sort of natural evolution the practice of each country has tended along the lines suited to the commercial environment. In Europe, coal is expensive and labor cheap. In the United States, gas and coal are very cheap, labor is dear, and our workmen have not had the training in zinc smelting of those in Germany and Belgium, where this calling has often been followed in the same family for three or four generations.

Consequently, the practices are radically different. The German metallurgist charges a small amount of coal, with a roasted zinc ore averaging something under 50 per cent of zinc, into muffles holding 80 to 100 pounds of ore. This is fired in regenerative furnaces with great care. At the end of the shift the residues are carefully scratched up by hand, sometimes without taking the condenser down, and the retorts are sometimes charged again through the mouth of the condenser. A great deal of labor is always used per retort.

In the United States the retorts are cylindrical and are charged very rapidly with a material high (in the case of Joplin ores over 70 per cent) in zinc. The furnaces are fired very extravagantly, usually with natural gas. At the end of the shift the residues are blown out by steam or water. In Kansas the aim is always to make a charge that contains so much coal and so little iron sulphide as to be non-corrosive, and leave "dry" residue—one that contains a minimum of slag. Very little scratching or cleaning of the retorts by hand-rabbling is done in this country. It will be seen that the practice of Europe and of America is different in these respects, by reason of totally unlike conditions in the two regions.

In the treating of ferruginous zinc ores from Leadville and elsewhere, American practice has been simply a refinement and a carrying out to the extreme of the method pursued with Joplin ores. The attempt is always to make a non-corrosive charge which, by reason of its large amount of fixed carbon, will also have a maximum reductivity at as low a temperature as possible. The criterion of this charge for low-grade ores is recognized by the practical zinc smelter in the glowing and brightening up of the residues when the condensers are "knocked down" in the morning at the end of the shift. If the residues then glow, it is, of course, a sign of the presence of active particles of carbon, to be attacked by the oxygen of the air which rushes into the retort. Consequently, the charge at the end of the shift still possessed considerable reductivity, and it was not necessary to use intense heat to reduce and distill the zinc. Did the charge contain no remaining active carbon it would not glow. The zinc smelters have almost a superstition about this glowing or "looking red" in the retort; and it is convincing to see that it has good chemical reasons.

Another fact about zinc reduction which I have never seen noticed, is that carbon deposition occurs around the iron oxide just as it does in the shaft of an iron blast furnace, and that this deposited carbon is very active in reducing the particles of zinc oxide.

The reaction of the iron-sponge on both zinc oxide and zinc sulphide increases, of course, the amount of zinc distilled. These reactions are both completed below 1,200° C. The iron is formed as an iron-sponge through the reduction of the iron oxide by the carbon of the charge. For this reason magnetic zinc blende, the so-called "marmatite," is very active.

Another characteristic of the reduction of zinc oxide is the distillation of the heavy tars in the coal. These heavy tars are distilled at about the temperature at which zinc is reduced, and are retained in the condenser, where they form a solid mass and in time choke the condenser. I have never seen this reason given before; but it is undoubtedly the chief reason why accretions are slowly formed on the sides of the condensers, which have to be cleaned out by the "connie boy."

The coal for a zinc charge should have maximum heat conductivity, "reductivity" (*i. e.*, active energy in reduction), and percentage of fixed carbon per cubic foot; and minimum proportion of hydrocarbons and of ash (the ash containing, moreover, a maximum of aluminium silicate). Finally, it should be low in price.

To combine all these good qualities in one kind of coal is impossible, and hence it is advisable to use three or four different kinds, one serving one purpose and another another. For instance, petroleum coke, the residue from the distillation of oil, contains from 94 to 96 per cent of carbon, and less than 1 per cent of ash; but it carries 3 or 4 per cent of heavy hydrocarbons. This would be an ideal reducing agent for zinc, did not its hydrocarbons choke up the condenser; and therefore it should not be used for more than one-sixth of the total fuel.

"Dead coal," from the "strip pits" of Missouri and Kansas, has carbon of good activity. The ash is also pretty infusible, because the sulphur has been extracted through weathering of the coal. It yields, however, a very high amount of gas, and therefore too much of it should not be used. Moreover, it is always well to use several kinds of coal, so that accidental poor shipments of one kind will be "averaged out."

All things considered, probably the best reducer for a zinc charge is anthracite slack, having less than 0.6 per cent sulphur and an ash which is nearly an aluminium silicate. It is, however, usually too expensive for use except in a few localities.

For maximum reductivity, neither the zinc ore nor the reducing material should be too fine. With coal and ore finer than 10-mesh, there will be channelling of the gases of reduction, and the very efficient reducing action of hydrocarbon vapors and carbon monoxide will be lessened. Besides, there is a "back pressure" of these gases, which retards reduction.

The ideal of American zinc practice should be to produce a charge of maximum reductivity with an infusible residue. If this were attained it might be possible to use much larger retorts, or possibly a gas-fired continuous furnace.

In this paper the word "reductivity" has been applied to the charge, the reducing agent and the ore, while possibly a stricter phraseology should have been used.

In conclusion, I want to express my appreciation of Dr. Percy's early work on zinc. Having repeated and extended all his experiments, I feel bound to testify that they reached the heart of the subject, and established principles not superseded by later progress. This is not true of all such pioneer work, however creditable it may have been in its day; and when it is true it deserves to be publicly declared.

I wish, also to acknowledge my indebtedness for valuable suggestions to Messrs. C. A. H. de Saulles, John Nett, Walter J. Chapman and many others.

Application of the Laws of Physical Chemistry in the Metallurgy of Iron.

By Baron von Jüptner.

(*Continued from page 440.*)

II.

For the calculation of the tensions of dissociation at any desired temperatures we can make use of the approximation formula established by Nernst.[1] Fig. 1 gives the logarithms of these dissociation pressures thus obtained. Fig. 2 these pressures themselves for a series of iron and manganese oxides between 600° and 2,400° absolute. In Fig. 1, curve 1

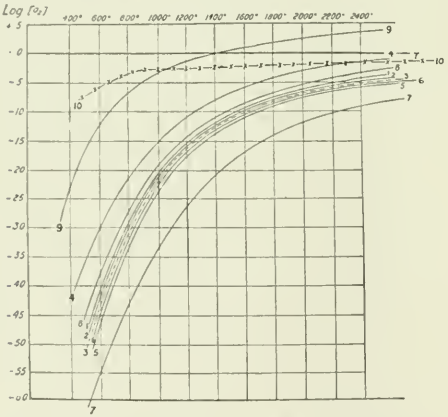


FIG. 1.—LOGARITHMS OF THE TENSIONS OF DISSOCIATION OF SOME OXIDES ACCORDING TO NERNST'S APPROXIMATION FORMULAE.

refers to $2FeO = 2Fe + O_2$, curve 2 to $2Fe_2O_3 = 4Fe + 3O_2$, curve 3 to $2Fe_2O_3 = 4FeO + O_2$, curve 4 to $6Fe_2O_3 = 4Fe_3O_4 + O_2$, curve 5 to $2Fe_3O_4 = 6FeO + O_2$, curve 6 to $Fe_3O_4 = 3Fe + 2O_2$, curve 7 to $2MnO = 2Mn + O_2$, curve 8 to $MnO_2 = Mn + O_2$, curve 9 to $2MnO_2 = 2MnO + O_2$, curve 10 to $Fe_3O_4 = Fe_2O_3 + FeO$. A comparison of these two figures shows that, for graphic representation, the logarithm serves far better than the pressure itself, since in Fig. 2 only three of the ten curves contained in Fig. 1 could be represented.

It must be mentioned that these curves can only be applied to the case in which the dissociation heats are independent of the temperature, which nearly happens for the dissociation of iron oxide $Fe_2O_3 = 2Fe + 3O$, since the heat of formation of this compound is at

	Calories.
1,000° C.	195,600
400° C.	197,700

so that 600° difference in temperature only alters their value by about 1 per cent.

[1] Gottinger Nachrichten, 1906.

Although the curves above mentioned can only be looked upon as approximations, yet they enable us to learn many things. An oxide will be decomposed so much the easier, the greater is its tension of dissociation.

Thus iron oxide gives off oxygen fairly readily at a white heat, and is transformed into Fe_3O_4. On the contrary, the decomposition of Fe_2O_3 into metal and oxygen is more difficult than that of FeO, which agrees with the experience obtained in the blast furnace. Consequently the reduction of Fe_3O_4 into FeO takes place first, and later that of FeO into Fe.

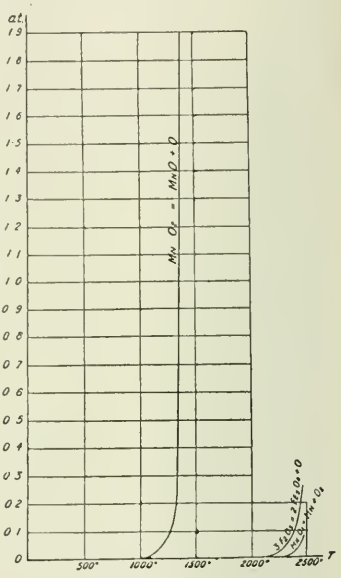


FIG. 2.—DISSOCIATION PRESSURE OF SOME OXIDES AT CONSTANT VOLUME.

The tension of dissociation of Fe_2O_3 when completely decomposed is larger than that of the simultaneous formation of FeO. There is, therefore, not an immediate reduction to metal, but FeO must first be formed. The same is the case exactly with Fe_3O_4.

MnO_2 is reduced more readily to MnO than to Mn. This arises from the fact that the tension of dissociation of MnO is exceedingly small. Further, if the MnO_2 be decomposed into Mn and O_2, the oxygen thus set free must immediately oxidize the metallic Mn into MnO.

The above curves also show that MnO_2 gives up oxygen more readily than iron oxide, but that inversely metallic Mn

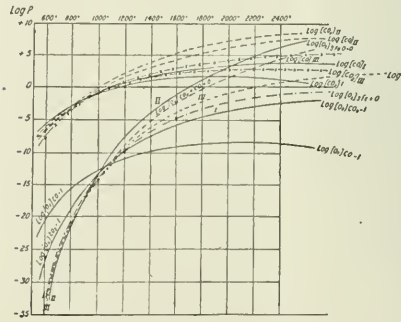


FIG. 5.—LOGARITHMS OF THE TENSIONS OF DISSOCIATION OF $FeO = Fe + O$; $Fe_3O_4 = 3FeO + O$; $Fe_3O_4 = 3Fe + 2O_2$; OF CO AND CO_2, AS WELL AS THE PARTIAL PRESSURE OF $[CO]$ AND $[CO_2]$ FOR CONSTANT PRESSURE.

must be able to reduce iron oxide to metal, which agrees with our experience.

It has been shown by Tholander that at a white heat in air, Fe_3O_4 gives off oxygen, and is changed into Fe_2O_3. The tension of dissociation, therefore, of the former must be greater at this temperature than the oxygen pressure of the atmos-

phere (0.21 atmosphere). According to our curve, both are equally great at about 2,300° absolute (2,030° C.). This agrees quite well qualitatively with this experience. Quantitatively, however, the agreement is less good, since according to White and Taylor's determination, a white heat commences at about 1,200° C.

From the beautiful experiments of Bauer and Glässner, as from those of Schenk and Heller, for some oxides of iron the relation between the tension of dissociation and temperature can be fixed nearer than is possible by the above approximation equations.

We thus arrive at the curves given in Fig. 2. These curves ought really to be considered trustworthy only up to about 1,600° absolute, since the experiments upon which they were founded only extended to about 1,200° absolute, so that further extra-polation must be regarded as somewhat risky.

With the oxides hitherto considered, we have been dealing with bodies, which, upon dissociation, do not themselves pass

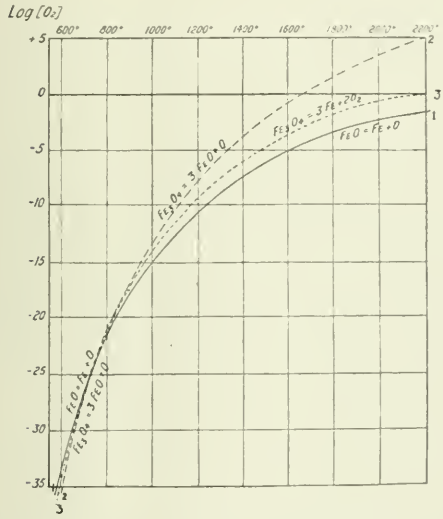


FIG. 3.—LOGARITHMS OF THE TENSION OF DISSOCIATION REACTIONS

$FeO = Fe + O$; $Fe_3O_4 = 3FeO + O$, and $Fe_3O_4 = 3Fe + 2O_2$ FOR CONSTANT VOLUMES (CALCULATED BY MEANS OF THE APPROXIMATION FORMULA).

into the gaseous state. Before we can enter upon the reduction of iron oxides we must deal with the dissociation of gaseous bodies.

As known, N_2O_4 decomposes according to the equation $N_2O_4 = 2NO_2$.

The dissociation stops when a given pressure of NO_2, that is, when a certain tension of dissociation is reached. But whilst, in the cases hitherto considered, this tension of dissociation was only dependent upon the temperature, it is here dependent also on the pressure of the simultaneously present still undecomposed N_2O_4 residue. As limit to the dissociation, we have then the expression

$$2 \log [NO_2] - \log [N_2O_4] = K$$

We can say, generally, *that the dissociation of gas-forming bodies comes to an end when the sum of the logarithms of the pressure exerted by the decomposition products (taken in the earlier sense) is as great as the logarithm of the pressure of the yet undecomposed residue of the dissociating body, plus the constant K.*

Now, since carbon, carbonic oxide and hydrogen come chiefly into question in metallurgical reduction processes, we must, first of all, learn the tension of dissociation of CO, CO_2, and H_2O.

The logarithm of the oxygen pressure of $CO = C + O$; $CO_2 = C + O_2$; $CO_2 = CO + O$; and of $H_2O = H_2 + O$ are graphically represented in Fig 4, for the case that the partial pressure of CO, CO_2 and H_2O are 1 atmosphere, since from this the value for other pressures is easily arrived at. With the help of these curves it is easy to study the reactions which come into play on the burning of coal with oxygen, as well as the production of producer gas, water gas, and mixed gas. But we will here confine ourselves to the reactions between iron and its oxides, on the one hand, and carbon, hydrogen, carbonic oxide, carbonic acid, and water.

Since for the oxides at a given temperature there is a certain fixed oxygen tension, a fixed equilibrium pressure of H_2O, CO and CO_2 for this change of action must also exist; a fact which has already been pointed out by Schenk. This equilibrium pressure can be directly derived from the curves of Fig. 5. But if these partial pressures of the reacting ma-

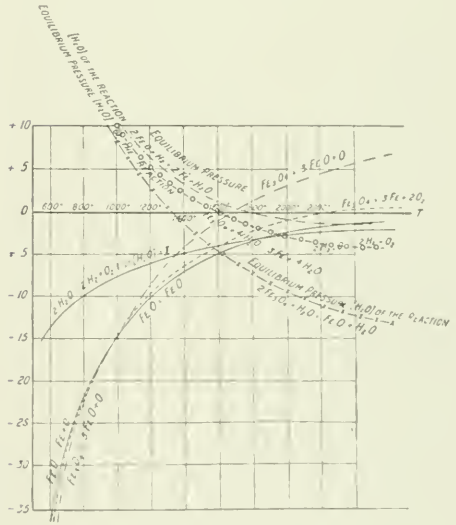


FIG. 4.—DISSOCIATION PRESSURE AND EQUILIBRIUM VAPOR-PRESSURE OF THE VAPOR OF WATER AND OF IRON OXIDES AT CONSTANT PRESSURE.

terials, in reference to the reaction products, are fixed, on the one hand, by the tension of dissociation of the oxides in question, so also must the rates between CO and CO_2 (which appear invariably together) for a given oxide for that temperature be a fixed one.

In Fig 6 this is represented, as it is calculated, on the one hand, theoretically, and also as Bauer and Glassner have experimentally determined it

In general both values agree well together, but at lower temperatures the Bauer curves show breaks which can be put down to the formation of more stable oxides. Thus, at lower temperatures the tension of dissociation of the FeO is greater than that of Fe_3O_4. A conversion of the former into the latter is therefore more likely, if the gas pressure is a proportionate one. For then the experiment must give results which approximate to the decomposition $Fe_3O_4 = 3Fe + 2O_2$, which is actually the case. But it is possible also that even more

stable oxides of iron exist, of which there are many indications.

[The concluding part of Prof. von Jüptner's paper will be published in our next issue. It deals with the application of the above principles to the consideration of blast-furnace practice.]

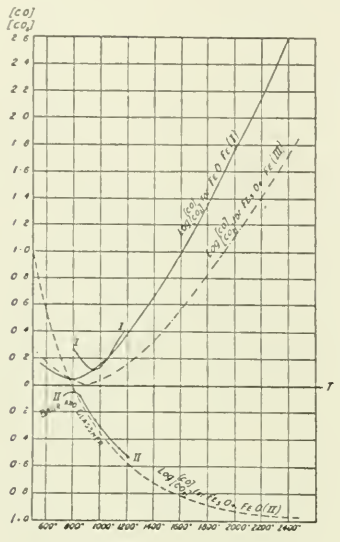


FIG. 6.—LOG $\frac{[CO]}{[CO_2]}$ FOR THE SYSTEMS CONSIDERED.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

An Electrochemical Exhibit at the Engineering Exhibition.

The Engineering Exhibition at Olympia this autumn is mainly a machine tool exhibition, and metallurgical developments are only emphasized by machines for dealing with the finished product of the iron and steel maker. One exhibit of an electrochemical nature may be chronicled. This was Messrs. J. Defries & Son's "Meridionizer Cell," for the production of hypochlorites. This firm have acquired the Digby patents for the United Kingdom. The method employed is that of a double diaphragm cell with porous diaphragms closely surrounding both anode and cathode, and the anolyte and catholyte kept out of contact with the main body of the electrolyte. Fresh water containing a little alkali or a little sodium chloride (to reduce its resistance) is run into the cathode compartment, and there combines with the liberated sodium to form a solution of sodium hydrate. The cathode liquor then passes through a special passage to the anode compartment, where, coming in contact with the nascent chlorine there liberated, forms a solution of sodium hypochlorite. In this process the proportion of unconverted sodium chloride in the resultant hypochlorite liquor is lower than in any other apparatus. The combined costs also are lower than those claimed for any other method. Acheson graphite is employed for both anode and cathode.

A Rehabilitation of the Large Gas Engine.

After the failure of the big gas engines at Johannesburg, large gas engines employing either producer gas or the waste gases from blast furnaces have been rather under a cloud. The troubles have been numerous, and the whispered, but unwritten, history of the large gas engine is vastly more portentious than the written history. All this is a great pity, for it is of prime importance that the large gas engine should prove its capabilities beyond any question, as so much can be done in large iron and steel works by the supply of electricity from a local power house where large internal combustion engines utilize the waste furnace and coke oven gases.

This month there has been a pilgrimage from London to South Germany of a specially invited party of electrical engineers and representatives of the technical press. They saw a large number of installations erected by their hosts, Messrs. Ehrhardt and Sehmer, of Saarbrucken, which embraced engines driving alternating-current generators, blowing engines and direct-current generators.

Germany certainly seems to have given both Great Britain and the United States a big lead in this branch of engineering. Very good evidence of this is given in a paper recently read by Mr. F. Sellge before the German Iron & Steel Works Society, on the difficulties met with in the working of large gas engines and methods of overcoming them, which contains an interesting statement as to the working results obtained at the Differdinger Iron & Steel Works, of which Mr. Sellge is the gas-engine manager. Before the introduction of gas power the amount of coal consumed for generating steam was 5,300 tons per month, the output of pig iron in the same period being 21,400 tons, of which 70 to 80 per cent was converted into steel and rolled, while the remainder was turned out as billets. The cost of coal at 18s. per ton was £4,770, or 4.46s. per ton of pig iron. When gas engines were installed the coal consumption diminished to about 500 tons per month, costing £450, while the output of iron has increased to 30,000 tons per month, the cost of fuel for power being therefore reduced to 0.3s. per ton of iron; assuming that under the former conditions with steam power the cost of fuel would have increased in proportion to the output of iron, the saving amounts to 4.16s. per ton, equal to £6,240 per month, or about £75,000 per annum.

Electric Pumping at Lindal Moor Mines.

A very interesting and comprehensive electrical pumping installation has been inaugurated this month at the Iron Ore Mines at Lindal Moor, where certain mines had been derelict for three years owing to the inrush of water. The following particulars of the installation are perhaps not out of place in this letter, as if the iron ore famine, regarded as inevitable by some leading metallurgists, is to be deferred, this postponement of an evil day can only be achieved by utilizing every advance of science in the battle with the forces of nature.

In the Lowfield pit, which is inclined at an angle of 43° to the vertical, two centrifugal pumping sets have been provided, each capable of delivering 4,000 gallons of water per minute against a total head, including friction, of 395 feet. On reaching a depth of 378 feet, where the two shafts join, these two pumps will be connected in series, and the design is such that when working in series they can together deliver the full quantity of 4,000 gallons per minute against a total head of 780 feet. These two pumps are of the one-stage type, and rest upon a special carriage running on rails having a gauge of 6 feet 6 inches.

Each pump has two wrought-iron delivery pipes, which are connected at the top by means of a Y pipe, which supports a rising main 14 inches in diameter. The check valve has an internal diameter of 375 mm. and a foot valve of 450 mm. internal diameter is fitted with strainer. Each

pump has a rope sheave 4 feet in diameter mounted on suitable brackets. Each of the motors direct coupled to these two pumps is capable of a continuous output of 750 b. h. p. when working on a circuit of 3,000 volts 50 cycles per second, and the speed of the combined set is 1,485 r. p. m.

In the Diamond shafts two vertical sinking pumps are provided, each of which is capable of raising 1,000 gallons of water per minute against a total head, including suction, delivery and pipe resistance, of 680 feet. These pumps are also fitted with direct-coupled motors having an output of 315 hp. at 1,480 r. p. m. These pumps are of the three stage type, and are fitted with elastic couplings and cast iron intermediate piece for connecting and centering the pumps with the motors. A breeches pipe is provided in each case, with wrought iron suction pipe 230 mm. internal diameter, foot valve and strainer; also two wrought iron delivery pipes connected at the top by a Y pipe, which supports the rising main. Each set is complete with check valve, by-pass and gate valve 225 mm. diameter.

In the Bercune pit are provided two pumping plants of similar design to those in the Diamond pit; but in this case each pump is designed for delivering 1,000 gallons of water per minute against a total head of 540 feet, the motors having an output of 250 hp., and the speed of each set being 250 r. p. m. These pumps are each of the five-stage type. The arrangement of valves and pipes is the same as for the Diamond pumps.

A three-phase alternating-current system has been adopted, and in order to transmit the required power without undue loss, and at the same time have a working pressure which could be used direct in the motors without transformers, a pressure of 3,300 volts, with a frequency of 50 cycles per second, was chosen.

The current is generated by three steam turbo-generators of the horizontal type, designed and constructed on the A. E. G. principle, each set being capable of a continuous output of 1,140 E. hp. when running at 3,000 r. p. m. and supplied with steam having a pressure of 200 pounds per square inch at the top valve, superheated to a temperature of about 600° F. Each turbine exhausts into a surface condenser of Messrs. Worthington's manufacture, specially designed for maintaining the high vacuum which is necessary for the efficient working of turbine plant. A special description of the A. E. G. turbines appeared in *The Electrician* of Dec. 14, 1906, and it will be remembered that they are designed on the velocity principle, steam being expanded and its pressure energy transformed into velocity energy in two stages, each pressure stage having two velocity stages.

The generators are of a particularly solid construction, the rotating field possessing the characteristic of a solid cylinder. By a special system of ventilation and by water circulation in a double casting round the stator and bearings, the entire generator is kept particularly cool. The circulating water flows by gravity under a head of about 20 feet from a tank situated above the engine room. The amount of water specified to be taken by each generator is 11 gallons per minute, but the amount can be regulated as required. This arrangement of water circulation is exceedingly simple, and the generator is kept perfectly cool, which is not always the case in turbine machines. The generator also runs practically noiselessly, owing to the construction of the stator, which does away with the noise often set up by the ventilating discs existing in other types of plant.

A special feature of the control arrangements is that each of the six pit motors is individually under the control of the power station engineer, the whole of the starting and stopping operations being carried out by means of the switchboard apparatus.

Two sets of bus bars are provided, one set for running the motors under full pressure, and the other for gradually raising the pressure at starting. The starting is effected by means of two transformers connected in series. One of these is an auto-transformer, which reduces the voltage to about half the working pressure; the second transformer has its primary connected in series with the auto-transformer, and its secondary connected to the liquid resistance, which is gradually short-circuited on starting the motors. By this means the pressure on the motors is increased gradually, and all large current rushes, which might in the ordinary way affect the voltage regulation of the station, are avoided. As soon as the motors have been run up to full speed on the auxiliary bus bars they are switched onto the main bars by means of change-over switches of the oil-break pattern.

Electricity in Rolling Mills

That our electric power supply companies are alive to the probable demands of this section of our manufacturing centers is clearly indicated from the following extract from the speech of the chairman of the Cleveland & Durham Electric Power Co., Ltd., at the annual meeting of the shareholders:

"It was no exaggeration to say that recent advances in this connection represented the most important development in the application of electricity to motive power purposes that had taken place during the last five years. This was much to say, in view of the fact that the applications of electricity in other directions had been so important, but a consideration of the magnitude of the iron industry in this and other countries more than justified the assertion. It now appeared certain that electricity would replace steam for all rolling-mill work, the lightest as well as the heaviest, and this, too, in the course of the next few years. As the Cleveland district produced between a quarter and a half of the iron of the United Kingdom, this development would eventually have an extensive and very favorable bearing on their company's progress."

The Finances of the Electrolytic Alkali Co., Ltd.

The directors' report for the year ended Aug. 31 states that the net profits for the year, after allowing for depreciation, mortgage debenture interest and expenditure on renewals, repairs and general upkeep of buildings, plant, machinery, tools, etc., is £8,212 plus £2,127 brought forward, making a total of £10,339. The hope expressed in the last annual report that further developments during the ensuing year would show better results has not been realized. The causes of this result have been entirely beyond the control of the board, the further increase during the year in the price of fuel, packages and other commodities which form the chief items of cost of the company's manufactures being mainly responsible for the decreased profit. The market prices of the company's products are abnormally low compared with those of other heavy chemicals, and the company has not participated in the advanced prices which were obtained during the period in other branches of their trade. Notwithstanding the result now shown, the directors have the fullest confidence that when normal prices have been reestablished the company will be able to make a satisfactory return to all the shareholders. Two and a half years' dividend on the preference capital has now accrued; but in view of the unsettled state in that portion of the chemical trade in which the company is engaged the directors think the wisest course is to pay only one-half year's dividend upon such shares; £6,840 is to be carried forward. The erection of the additional plant is nearing completion. It has not been possible to get any benefit from this during the past year, while the expense of issuing debentures needed to pay for such plant and the interest on them have been charged against revenue. The same rates of depreciation as in past years have been maintained, and an increased amount for renewals and repairs necessary to keep the buildings, plant, machinery and tools in a high state of efficiency, is also charged against the

year's results. The demand for the products of the company is extremely satisfactory. The directors hope to have the new installation in operation at an early date, when they will be in a better position to deal with the increased volume of business which has already been secured.

Market Prices During October.

The price of bleaching powder at the end of October was, for 35 per cent., £4.7.0 per ton. Caustic soda, 77 per cent., £11 2.6., ammonia sulphate, £12.0.5. and copper sulphate, £22 10. Shellac was £11 per cwt.

Regarding the metal prices: Copper opened at £63.5 per ton, and, after falling to £61.10 on Oct. 3, rose to £64 on the 7th; then followed a continuous fall to £55.10 on the 23d, with the exception of a slight rally on the 15th. From the 23d to the end of the month a sharp rise occurred, £62 being reached on the 28th.

Cleveland pig iron was 55s. per ton on Oct. 1; it fell to 54s. 3d. on the 2d; and, rising to 55s. 10d. on the 7th, fell to 54s. 4d. on the 10th; a rise to 55s. 3d. occurred on the 11, followed by a fall to 53s. 8d. on the 15th, and continuing fairly steady until the end of the month, closing at 54s.

Hematite fell almost continuously during the month, opening at 75s. 6d. it remained steady at 73s. 10d. from the 8th until the 11th; fell to 73s. on the 14th, at which price it remained with the exception of a slight fall to 72s.10d. on the 17th, until the 18th, then falling to the closing price of 71s.

English lead also fell continuously during October, opening at £21.15 to £22, and closing at £18.15 to £19.

London, November, 1907.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS

Electric Furnaces.

Resistor for Electric Furnace.—Frank J. Tone, 870,326, Nov. 5, 1907. Application filed March 7, 1905.

A "self sustaining resistance conductor" is obtained by putting together a series of regularly shaped blocks in form of a vertical or horizontal column. The resistance of this resistor is the sum of the resistances of the carbon blocks themselves and of the contact surfaces. By making the number of contact surfaces large in proportion to the linear dimension of the resistor in the direction of the current a high resistance can be obtained. By using a continuous rod it would become necessary to make the resistor much longer and thinner, while by assembling a number of carbon blocks together greater mechanical strength can be obtained.

Electric Furnace.—P. L. T. Héroult, 871,273, Nov. 19, 1907. Application filed May 3, 1907. Assigned to Société Electrometallurgique Française.

For regulation of the power supplied to an electric furnace, without moving the electrodes themselves, a false or dummy electrode is employed. By varying the position of this false electrode, which is of greater conductivity than the material of the charge, the total resistance to the passage of the current between the two electrodes is varied. This false electrode may be easily shifted, since it does not require any electrical connections or sliding stuffing boxes, etc. In Fig. 1 the hearth A forms one electrode and the ring C of carbon at the top the other electrode, while E is the false or dummy electrode, consisting of a stick of carbon and adjustable in its vertical position.

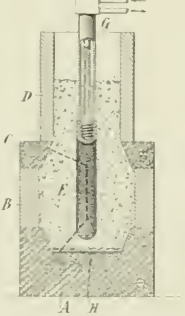


FIG. 1.—DUMMY ELECTRODE FOR ELECTRIC FURNACE.

Electric Furnace.—P. L. T. Héroult, 871,338, Nov. 19, 1907. Application filed April 21, 1906. Assigned to Société Electrometallurgique Française.

For the purposes explained in our Vol. IV., page 152 a hollow carbon electrode is used, the fuel for reduction being introduced through the electrode separately from the ore. The electrode is held by a stuffing-box of copper, which is internally cooled by water or air and serves at the same time for making electric connection, the usual cable box being bolted to a projection of the stuffing-box. The electrode slides downward through the stuffing-box as its lower end is consumed, and it is important to obtain a good contact between the stuffing-box and the electrode. For this purpose divided rings of conducting material are employed which surround the electrode, the adjacent rings having contact surfaces which are wedge-shaped so that the pressing of them together not only makes a more intimate contact between them but also makes a more intimate contact of one of the rings with the electrode.

Carbon Tetrachloride. Fred. J. Maywald, 870,518, Nov. 5, 1907. Application filed Oct. 6, 1902.

A furnace with two carbon electrodes is filled with lumps or nodules of coke, preferably of the size of a hickory nut, and by passing the electric current through the mass the coke is brought to incandescence. When a stream of chlorine gas is then passed through the furnace it is said to combine with the incandescent carbon in the proper molecular proportions to form carbon tetrachloride CCl_4.

Electrolytic Processes.

Lead-White and Lead-Chromate by Electrolysis.—E. D. Chaplin, 871,161 and 871,162, Nov. 19, 1907. Applications filed Feb. 3, 1906. Assigned to International Lead Cos.

Patent 871,161 refers to the electrolytic production of lead-white. A solution of sodium nitrate and sodium chlorate is supplied to the middle compartment of a three-compartment electrolytic cell, and the level of the solution is maintained higher in the middle compartment than in anode or cathode compartments, so as to prevent mixing of the anolyte and catholyte. The anode is made of lead and the cathode of copper. The product at the cathode is sodium hydrate, while at the anode lead-nitrate is probably first formed, which is then converted into lead-oxychloride, which is soluble at the elevated temperature at which the electrolyte is maintained by means of a steam coil. The lead-oxychloride being an acid salt of lead renders impossible the formation of insoluble basic salts of lead. The sodium hydrate is converted in a separate tank into sodium carbonate by the action of carbon dioxide, and the sodium carbonate is then mixed with the lead-oxychloride, converting the latter into lead carbonate. The latter is collected by filtration while the filtrate is substantially the original electrolyte and is used over again.

Patent 871,162 refers to the production of lead-chromate. The first part of the process is the same as in the preceding patent. The lead-oxychloride is converted to lead chromate by treating it with a mixture of sodium chromate and bichromate. To produce the latter the sodium hydrate, produced in the electrolytic cell, is made use of. It is mixed with a solution of chromate alum. By producing an excess of sodium hydrate, chrome hydrate is precipitated and redissolved. It is mixed with sodimum chloride and subjected to electrolysis,

whereby a mixture of sodium chromate and bichromate is produced.

Arsenic Compounds of Lead.—Cornelius D. Vreeland, 870,915, Nov. 12, 1907. Application filed Feb. 5, 1906.

A series of lead anodes are placed in a cell filled with a solution of sodium nitrate. Between every two succeeding anodes a porous cup is placed containing sodium hydroxide solution and an iron cathode. The action of the current is the formation of lead nitrate at the anode while at the cathode sodium hydroxide is reformed and hydrogen is given off. During electrolysis a solution of a sodium salt of arsenic, for example, sodium arsenate, is introducted continuously into the anode compartment in just the proper quantity to react with the lead nitrate formed, yielding lead arsenate and sodium nitrate. The lead arsenate being a heavy insoluble substance, is precipitated out of the solution and settles to the bottom of the vessel, whence it can be drawn off in any suitable manner. The first claim refers broadly to "the process of manufacturing arsenic compounds of lead, which consists of the formation of a soluble salt of lead by electrolysis in the presence of a soluble compound of arsenic and the simultaneous precipitation of the lead thereby as an arsenic compound of lead."

Plating Device.—G. W. Clough, 870,545, Nov. 12, 1907. Application filed Oct. 10, 1906.

For electroplating heavy articles, a rocking receptacle is provided by means of which the articles are forced to roll or tumble about so as to be plated on all sides. It is a trough with an angular bottom, an angle of 45° or more being most convenient. A curved bottom may also be used. The cathode consists of metallic strips in the sides of the trough, which are connected to conducting bars at the top of the trough.

Apparatus for Electrochemical Analysis.—G. A. Guess and H. E. T. Haultain, 870,674, Nov. 12, 1907. Application filed April 26, 1906.

The invention comprises essentially a bench of adjustable beaker stands, in connection with a series of terminals in sets of three supplied with electrodes and connected up in circuit in various ways. They are adapted to be short circuited so as to cut out any particular assay or vary the current flowing through it without effecting the others.

Electrode.—G. A. Guess and H. E. T. Haultain, 870,675, Nov. 12, 1907. Application filed April 26, 1905.

A light and cheap electrode for electrochemical analysis consists of a thin platinum sheet, having a blade corrugated lengthwise, to render it rigid and a tang or shank adopted to be frictionally engaged in a slitted terminal or binding post. Only the blade is immersed in the electrolyte. With three electrodes placed equidistant, the two outer ones being anodes and having comparatively narrow blades, a uniform deposit is obtained on the middle electrode which is the cathode.

Carbon Electrode.—W. Mollenbruck and W. Diehmann, 870,985, Nov. 12, 1907. Application filed Oct. 23, 1906.

The electrode consists of a number of carbon rods circularly grouped or of an ordinary carbon cylinder or of a cylinder composed of lead carbon rings placed one on top of another, a central cavity being thus formed from end to end. Within this cavity a removable but snugly fitting carbon rod is placed protruding from the cell. This is the only movable part, and in case of breakage it can be easily renewed.

Reducing Formic Acid.—Carleton Ellis and K. P. McElroy, 867,575, Oct. 8, 1907. Application filed May 2, 1907.

The object is to reduce formic acid to produce methyl alcohol formaldehyde and condensation products. This is done by electrolysis in the presence of a strongly dissociated acid; a 10 per cent solution of sulphuric acid is said to be suitable. The electrolysis is carried out in a diaphragm cell, the formic acid being added to the sulphuric acid in the cathode department. The reduction of the formic acid is thought to be secondary and due to the H ions set free at the cathode. Two main reactions are possible: a replacement of the saturating oxygen of the carboxyl by hydrogen with formation of methyl alcohol or a replacement of the hydroxyl by hydrogen forming formaldehyde. A low current density favors the formation of formaldehyde, while a high-current density gives a greater proportion of methyl alcohol. Lead cathodes or spongy nickel-iron or cobalt cathodes are advantageous. The presence of a catalytic agent, such as cerium salts, is advantageous. When the acid liquid is withdrawn from the cathode compartment, the methyl alcohol and formaldehyde formed are distilled out and thereby shielded from further reduction and the acid is returned to the cell for further use.

Batteries.

Storage Battery.—J. C. Cook and E. Sokal, 870,015, Nov. 5, 1907. Application filed May 10, 1905.

The plate represents a combination of Plante and Brush formation. A lead plate is provided with numerous closely-arranged spurs, pins or projections about half an inch long so that the surface has a brush like appearance. Over the surface of the plate and around the base portions of the spurs or equivalent projections, a paste is applied as in ordinary Brush plates, while the large superficial area of lead is constituted by the exposed portions of the projections is subjected to the Plante action in service. The layer of paste should be of sufficient thickness to give the plate a suitable capacity. A considerable portion of the projections extends into the electrolyte, and by charging and discharging in clear dilute sulphuric acid the same are formed according to the Plante process without any unusual expenditure of time or current and without the use of obnoxious additions to the electrolyte.

Storage Battery.—T. A. Edison, 871,214, Nov. 19, 1907. Application filed Oct. 31, 1900. Assigned to Edison Storage Battery Co.

This is one of the early applications of Mr. Edison for his storage battery and covers broadly some of its features. The first claim reads as follows: "In a reversible galvanic cell, an alkaline solution; an electrode consisting of an insoluble metallic perforated inclosing pocket, and a finely divided insoluble active material tightly packed in such inclosing pocket, and a second electrode." Metals suitable for the active masses of the electrodes are said to be cadmium for the positive element and copper oxide for the negative element.

Storage Battery.—H. E. R. Little, 870,073, Nov. 12, 1907. Application filed Jan. 17, 1907.

The cell is divided by a horizontal asbestos diaphragm into two compartments and carbon rods placed both in the lower compartment and in the upper compartment from the electrodes. The lower compartment is filled with carbon tetrachloride (or in general any liquid solvent of bromine, with a higher specific gravity than zinc bromide). The upper compartment is filled with zinc bromide. To charge the cell the carbons in the lower compartment are made the anodes and those in the upper compartment the cathodes. Zinc is deposited on the upper carbons while bromine is absorbed by the carbon tetrachloride. In discharging, bromine is withdrawn from the solution of carbon tetrachloride and zinc dissolves from the upper electrodes.

Discharges Through Gases.

Ozonizer.—Frank A. Ward, 871,052, Nov. 19, 1907. Application filed Aug. 23, 1906.

Air is purified by means of ozone produced in an ozonizer of the following construction. Within a cylindrical glass vessel a metallic rod is placed in the direction of the axle of the cylinder and a series of metallic discs are mounted on this rod at suitable intervals. Their peripheries or edges are notched to form points, which touch the inner surface of the glass cylinder. This forms one electrode. The other electrode is in form of a metallic cylinder which snugly fits the outer surface of the glass cylinder. This metallic cylinder is perforated

RECENT METALLURGICAL PATENTS

Iron and Steel.

Open-Hearth Process.—An interesting improvement in open-hearth steel production is described by Anson W. Allen (870,921, Nov. 12, 1907). Mr. Allen is the superintendent of the steel department of the A. & P. Roberts Co., Pencoyd, Pa. He finds that important improvements can be obtained by charging in a basic-lined open-hearth furnace a charge of iron and burnt lime, heating the same and then pouring upon the heated charge of lime and iron oxide a charge of molten metal. When this is done, a reaction immediately ensues in which the phosphorus and silicon of iron are caused to combine with the iron oxide and lime, forming a molten slag, so that the iron rapidly becomes dephosphorized and desiliconized. This reaction is not violent, and does not cause the overflow of the slag, and the slag containing the phosphorus and the silicon is allowed to remain floating on the surface of the metal. It is dense in its nature, and is not foamy and does not interfere with the transmission of heat to the iron below. The advantage of thus leaving the slag or the bulk of it remaining in the furnace is that a very large saving of iron is effected thereby. If the slag is immediately tapped off after a violent reaction, a large part of the iron oxide passes with it; but by allowing it to remain in the furnace the iron oxide contained in the slag reacts with the charge of molten iron decarbonizing it and giving up the iron of the slag to the bath. Scrap may be introduced into the furnace as part of the original charge, although an important advantage of the invention is that it is possible to conduct the open-hearth operation without the use of scrap. The following heat was made by the inventor: On the bottom of the furnace a charge of scrap steel was introduced, and upon it was placed iron oxide in the form of mill scale amounting to about 20 per cent of the metal charge of the furnace, and burnt lime amounting to about 4½ per cent thereof. Scrap was then placed on top of the lime and oxide, the total amount of scrap equaling about 20 per cent of the metal charge of the furnace. These materials were then heated for a period of one hour and a half until the iron oxide began to sweat or show signs of incipient fusion. Molten metal was then added to the furnace, it being introduced in two lots at an interval of 35 minutes apart. Each portion introduced amounted to 26,850 pounds and containing approximately 3.8 per cent of carbon and 0.8 per cent of phosphorus. At the introduction of the first lot of molten iron to the furnace a reaction took place which was quiet in its nature and not violent, and which produced a rapid elimination of the phosphorus from the metal, so that in 5 minutes the phosphorus was reduced to 0.612 per cent; in 10 minutes to 0.396 per cent; in 15 minutes to 0.288 per cent, and in 20 minutes to 0.070 per cent. On the introduction of the second ladle of iron, which was made 35 minutes after the pouring of the first ladle, a supplemental reaction ensued, and in five minutes thereafter the charge in the furnace contained .392 per cent phosphorus; in 10 minutes it contained .268 per cent phosphorus; in 15 minutes it contained .224 per cent; in 25 minutes .097 per cent phosphorus, and in 45 minutes .016 per cent phosphorus. The carbon was eliminated from the metal more slowly, and the entire heat lasted 4 hours and 55 minutes. The total metal output of this furnace was 72,390 pounds, or 6,520 pounds more than was charged into the furnace in the form of metallic iron, the addition being obtained from reduction of the iron ore. The slag was tapped from the furnace at the end of the heat, and was not removed previously. When tapped it contained 14.15 per cent of iron. The operation of the furnace was very rapid, and the inventor states that by following this process he is enabled to largely increase the output. For example, a furnace which previously yielded twenty 30-ton heats per week, by the new process will now yield twenty-six 30-ton heats per week. The advantages of the process are due to the fact that it enables one, without the use of the large scrap charge ordinarily employed in the pig and scrap process, which amounts approximately to 50 per cent or more of scrap, to produce basic open-hearth steel rapidly and with a minimum of labor and with a minimum of waste of iron, the essentials of the invention being the use of burnt lime as part of the initial heated charge of the furnace, and the retaining of the slag or the bulk of the slag in the furnace after the initial reaction takes place, in order that the iron of the slag may not be lost. If desired, mill cinder or iron may be substituted in whole or in part for the roll scale as the iron oxide to be employed in the reaction.

Sintering Flue Dust or Fine Ores.—James Scott, of Pittsburg, Pa. (865,658 and 865,659, Sept. 10), conglomerates finely divided ores or flue dust of blast furnaces, by dropping the fine dust in a shower through a furnace chamber, into which burners project in annular series at different levels, the heat being so regulated that the ore will be partially fused and concentrated during its drop through the chamber. The burners substantially provide annular sheets or flames at different levels through which the showering ore must drop. The bottom of the chamber is provided with a feed-out device, which aids in forming the partially fused material into lumps and discharges them into a water bosh, from which they are carried into a car by means of a conveyor which passes through this water bosh.

Copper.

Treatment of Low-Grade Copper Ores.—John A. Haralson, of Mexico, Mex. (807,360, Oct. 1) proposes to win copper from very low-grade ore in the following manner: A mixture of calcium sulphate and charcoal is heated in retorts to produce calcium sulphide and carbon dioxide. The latter gas is stored in a gasometer. A set of hydrogen-sulphide gas generators is filled with water, and in it the calcium sulphide is held suspended by bubbling the gas from the gasometer through the water upwards from the bottom. An ore mixer is filled with the crushed ore and a weak solution of sulphuric acid, whereby the copper is leached out. The gas, which is developed is led to the gasometer mentioned above, while the mass of ore and copper sulphate solution is discharged into a filter which separates the solution from the solid matter. The solution is run into a receptacle, where the copper is precipitated by means of hydrogen sulphide. The copper sulphide is roasted and the sulphurous fumes are worked up into sulphurous acid.

Smelting Copper Ore and Converting Copper Matte.—Arthur M. Day, of Bingham Canyon, Utah (865,333, Sept. 3), patents a process in which the apparatus shown in vertical and horizontal section in Fig. 1 is used; *a* is a smelting vessel or converter with a nozzle *b* at the top and a wind-box *c* at the bottom. A number of tuyeres *f* extend upwards through the bottom, and for some cases they are provided with fusible tubular extensions *b* which extend from the bottom of the vessel to the top of the charge. The trunnion *d* is hollow, and is connected with the wind-box by a passage *g*, a compressed air supply pipe *h*, being detachable, connected with the trunnion. There are, further, several closed reservoirs *i*, each being provided at the top with a compressed air supply pipes *j*, while at the bottom connection is made with one or more auxiliary compressed air supply pipes *l*. Each of the pipes *l* is connected by a hose *n* with a pipe *o* leading to one of the tuyeres *f*. One of these reservoirs *i* is filled with powdered silica, a second

with powdered coal, coke or with oil, and still another with a flux, such as powdered limestone or iron ore. The vessel *a* is charged with the ore to be smelted; for instance, with crude copper sulphide ore, and is then tilted to receive molten matte through the nozzle *b* to start the smelting operation. This begins at the top of the charge, the air supply through the tuyeres being now turned on. The smelting progresses gradually downwards, and as the operation proceeds the smelting vessel is turned and the molten silica is drawn off from the surface through the nozzle. As the melting level progresses downward the tuyere extensions *p* are melted off and the air is delivered to the top of the ore next to the melted covering. When it is feasible the ore is mixed so as to produce a self-fluxing charge, but when this is not practicable the flux required to properly fuse the charge is supplied from one of the reservoirs *i* through one of the tuyeres. The oxidation of the sulphur and iron in the ore ordinarily produces sufficient heat to smelt the ore, but if this is not the case, powdered fuel is supplied from a second reservoir *i* through one of the tuyeres. To keep all the tuyeres open, a small quantity of powdered

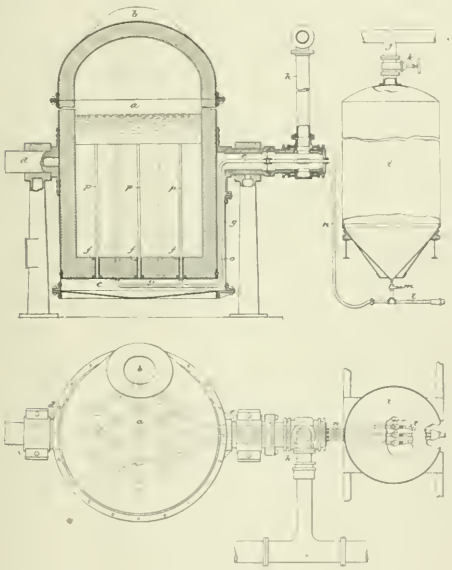


FIG. 1.—CONVERTER.

silica, silicious ore or other silicious material in a fluent form is supplied from a third receptacle *i* to one or more of the tuyeres. The silica or other silicious material injected into the charge, while it is being agitated by the air blast, is diffused through the entire charge and brought into contact with the iron which is contained in the charge and with which it combines and forms a fluid slag. The chemical reaction which thus takes place throughout the entire molten portion of the charge, while the demand of the iron for silica is being satisfied, operates to keep the tuyeres open. In this way drifting or thrusting rods or bars through the tuyeres from time to time to keep them clear is avoided.

For the conversion of copper matte into pig copper the tuyere extensions *p* are not required, the air with the powdered silica being delivered directly from the tuyeres *f* into the lower part of the converter *a*. It will be seen that the chief feature of the process consists in the introduction of powdered silica through one or more of the tuyeres into the charge. The object is three-fold. First, to keep the tuyeres open without drifting; secondly, the silica combines with the iron contained in the matte and thereby liberates the copper; thirdly, this method admits of the use of ordinary fire-brick or clay linings in the smelting vessel of converter bowl, and thereby does away with destructible silicious linings.

Precipitation of Copper from Sulphate Solution.—Cement copper precipitated from copper sulphate by means of scrap iron requires purification. L. Jumau, of Paris, France (870,786, Nov. 12, 1907), claims to produce pure copper by heating the copper sulphate solution under pressure in the presence of a suitable sulphite such as ammonium sulphite or sulphurous acid. The copper is precipitated, while the sulphite is oxidized to sulphate or the sulphurous acid to sulphuric acid. The process is carried out in a digestor lined with lead, at a temperature of 170° C.

Lead.

Lime Roasting.—A patent relating to this interesting subject has been granted to A. Savelsberg (870,690, Nov. 12, 1907). His argument is as follows: The desulphurization of sulphurous ores has been carried out in dividing the roasting process into a preliminary roasting in a revolving reverberatory furnace with the use of combustible material and into a final roasting in a converter. It would be advantageous to carry out both steps in the converter, but when this is fired the ore sinters during the preliminary roasting (which is not the case in the revolving reverberatory furnace, on account of the continuous stirring of the ore). This disadvantage must be overcome by mixing with the ore a material which can be easily made to swell and break up the sintered mass so as to make it suitable for the final roasting. Such a material is limestone, the swelling is produced by moistening. The process is, therefore, as follows: Limestone is mixed with the sulphurous ore and blowing in the converter begins. The ore is partially desulphurized and sintered together; the added limestone being contained in the mass partly in form of CaO and partly as $CaSO_4$, and partly, but least of all, as silicate. The superficially sintered mass has the shape of the converter, but still contains too much sulphur for the subsequent shaft-furnace process, and must therefore be desulphurized in a second blowing process. But for this purpose it must be pulverized, and this is simply done by pouring water over the sintered mass. The burned lime contained in it has an explosive effect when the water is soaked up so that the sintered mass is shattered, and can easily be brought into the state suitable for a second blowing process. In the case of ores which have the property of decomposing with subsequent damping with water in consequence of their own composition, no limestone is needed. The limestone, as well as the ore at the first blowing, may be employed in fairly coarse form. It would not be possible to roast to a finish by a single blowing in the converter in one operation, because the product which would become a hard sintered mass would contain too much unroasted sulphide ore and undecomposed sulphites enclosed within the roasted mass.

Sulphide Ores.—F. Dedolph of Marysville, B. C. (870,668, Nov. 12) proposes the following treatment of sulphide ores of lead, copper, etc. The finely ground ore is intimately mixed with finely divided carbonaceous fuel, like sawdust, and is roasted in such a fashion as to oxidize the sulphur and a portion only of the fuel. The resulting product, consisting of the roasted ore and the unconsumed fuel, is then smelted. The following illustration is given. To a charge of 1 800 pounds of the ground ore about 50 pounds of sawdust are added. After the charge has been thoroughly mixed, it is roasted in an ordinary roasting furnace in the usual manner until all the sulphur fumes have been driven off. During this operation the volatile constituents of the sawdust, probably about 75 per cent thereof, are consumed, thus saving external fuel. The dense sulphur atmosphere formed in the roaster prevents the oxidation of the resulting fixed carbon or charcoal

and at the end of the roasting this remains intimately incorporated with the ore. During the smelting, which is carried on in a blast furnace in the ordinary manner, the 25 per cent of residual fuel, amounting to about 12½ pounds of finely divided charcoal, saves in the neighborhood of about 30 per cent of coke, or 54 pounds per charge, and this saving is practically clear gain, since the cost of the sawdust is negligible. It is stated that with this process it is possible to smelt ore running 70 per cent zinc.

GOLD.

Slimes Filter.—D. J. Kelly and J. M. Callow, of Salt Lake City (805,912 Sept. 10, assigned to Kelly Filter Press Co., Salt Lake City), use a filtering apparatus consisting of a tank in which a carriage runs on tracks carrying the filters. Whenever the filters are heavily charged with separated solid material, and it is desired to remove the collected solid matter from the sides of the filter frames, the carriage is run out of the tank on to an exterior trackway. The special features of the present patent are details of construction of a locking-head connection between the pressure tank and the filter-frame carriage, by which a perfectly tight joint is formed around the open end of the tank to prevent any leakage at this point, and to securely lock the filter-frame carriage in its position in the tank.

Filter.—J. B. Stewart, of Peregina, Mex. (866,401, Sept. 17) patents a filter in form of a cylindrical drum with attached conical ends. The casing of the drum is perforated and carries a filtering cloth. Concentrically with this outer casing there

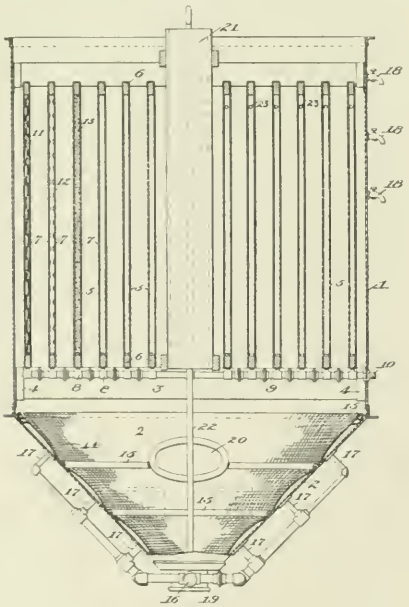


FIG. 2.—FILTER.

is provided an inner casing, so as to leave an annular space between the two casings through which the slime passes from one end to the other end. The inner casing is also perforated and is divided up into several compartments, which are connected by pipes to different solution tanks, so that the slimes are treated with different solutions while passing along through the annular space from one end of the drum to the other end.

Filter.—W. A. Hendryx (870,289, Nov. 5, 1907) patents the filter shown in Fig. 2. A charge of material is introduced into the tank through the box of pipe 21, while wash water, etc., is introduced through the pipe 16, passing by the several branch pipes 17 to the spaces beneath the canvas filter 14. The liquid thus introduced passes upward through the body of the ore pulp and is discharged through the filter cells 5. These filter cells are supported by transverse bars 3 and each cell comprises a wooden framework 6 with filter bags 7 of canvas. Each filter cell has a discharge 8 at the bottom connecting with the common main 9, which has an outlet 10. In order to prevent the collapse of the walls of the filter cells, they are filled with flexible cocoa matting, as shown in 11, or the walls are held in place by means of wooden strips 12, or the filter cells are filled with wooden blocks, as shown in 13. This filling of the filter cells does not prevent the passage of the liquid. The filter 14 serves as a very effective distributor for the inflowing liquor, while the cells 5 serve to distribute the outflowing liquor. In case the displaced liquid is substantially clear, the same or any portion of it may be decanted through the cocks 18.

MISCELLANEOUS.

Melting Furnace.—Edward H. Schwartz (871,070, Nov. 12, 1907, assigned to Hawley Down Draft Furnace Co.) patents the furnace shown in Fig. 3. It is in form of a cylinder with conical ends. The end opening 8 is intended for pouring or

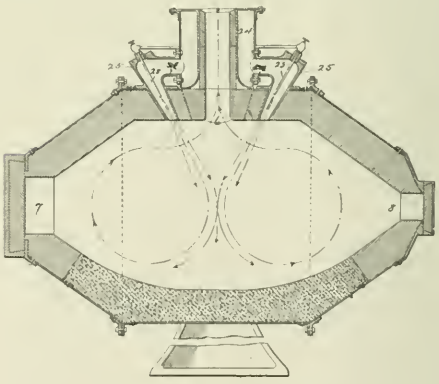


FIG. 3.—MELTING FURNACE.

tapping, and the opening 7 for charging. There are two burners 25, entering the top of the furnace on either side of the outlet opening 6, oil being supplied through the injectors 28. There are thus produced two flames which converge and meet at the central point of the furnace and form two rotary flames, as indicated by the dotted lines. During the melting operation the charge and the pouring openings are closed and the flames and products of combustion pass downward through the outlet 6 and the outlet extension 24, thereby heating the air in the latter chamber. Hot air is therefore introduced into the burners and a hotter and better flame is produced.

Furnace Doors.—In connection with the increasing use of electric power in steel mills, a patent of John C. Cromwell (869,960, Nov. 5, 1907, assigned to Garrett-Cromwell Engineering Co.) is interesting. It provides for electric operation of the furnace doors instead of the usual hydraulic operation. The front of the furnace has several ways in which the furnace doors may slide up and down, and each door is lifted through a chain connection by an individual electric motor, and is allowed to fall by its own weight. The several motors are hung on the frame of the furnace, so that they move therewith and occupy the same relative position to

the other parts in all positions of the furnace, which is a great advantage in case of a tilting furnace. The details of construction appear to be well worked out so as to make the arrangement fool-proof and the operation of the furnace doors as independent as possible of carelessness of the operator.

Reduction Without Smelting.—John D. Jones, of Iron Mountain, Mich. (866,280, Sept. 17, 1907), proposes to recover iron, manganese copper, etc., in form of pure metal from the ore, by putting the crushed ore, mixed with coke, into a stack of a height of about 100 feet. From a fire-box at the side of the stack at its bottom the products of combustion from soft coal are passed upwards through the mixture of ore and coke in the absence of air and without melting the ore. The combustion gases are mixed with the volatilized hydrocarbons from the soft coal.

Colloids.—In an editorial note in our November issue we discussed the various practical applications which the colloidal state now finds in the arts. A patent of Hans Kuzel, of Baden, Austria (871,599, Nov. 19, 1907), is interesting, since Kuzel has claimed to use colloidal tungsten for making the filament of his electric tungsten lamp. The method described in the patent is suitable for bringing highly refractory metals like tungsten, chromium, manganese, etc., into the colloidal state. For this purpose, the metal is first powdered as finely as possible, and is then subjected to treatment with various chemical reagents in alternating succession for more or less lengthy periods under moderate heating and energetic agitation. The best way is to first employ a solution of an acid character, and to follow this by a solution of a basic or neutral character, and then by a washing by diluted water or such organic liquids in which the solutions used are soluble, for instance alcohols, and so on. In the case of tungsten, the procedure is as follows: 10 kg. of tungsten are very carefully reduced to an exceedingly fine powder, and are then heated to a temperature of less than 100° C. for from 24 to 48 hours in a water bath with 75 kilograms of 15 per cent hydrochloric acid under thorough agitation and repeated renewal of the hydrochloric acid, and then separated from the acid by decantation and washed in the same way with distilled water until the hydrosol already formed begins to go into colloidal solution. The washing is interrupted and 75 kilograms of a 1 per cent solution of potassium cyanide are added to the substance and heating in the water bath under thorough agitation for about 5 to 24 hours again takes place, whereupon after washing with distilled water thorough agitation with a solution of acid character for instance, 75 kilograms of a 1 per cent solution of ferrous sulphate for about 24 hours, takes place in a water bath. After this treatment and after complete removal of the iron by washing with distilled water, as a solution of basic character, for instance, a 2 per cent alcoholic solution of monomethylamin or a 0.5 per cent solution of caustic soda may be used, and so on. If the raw material was a sufficiently fine powder, a repetition two or four times of the treatment described above brings the tungsten into colloidal solution with distilled water. The colloidal tungsten may be readily and completely precipitated by the addition of a small quantity of an electrolyte for instance, sodium chloride, and separated from the water by decantation.

Oxone and Regeneration of Air.

The Roessler & Hasslacher Chemical Co. have received a gold medal for their exhibit of oxone and other products of their works at the Jamestown Exposition, while Dr. Richard von Foregger has received a silver medal for the process of regeneration of air by oxone, which was in practical use in the Radium Booth of the Government. We will describe these interesting exhibits in full in our next issue.

SYNOPSIS OF PERIODICAL LITERATURE

A Summary of Articles Appearing in American and Foreign Periodicals.

IRON AND STEEL.

Shrinkage Cavities in Steel Ingots. Engineer A. Ohlholzer, in *Stahl und Eisen* for July 31 and Aug. 7, gives the results of using "Thermite" in the tops of heavy ingots to increase their solidity. Some fine photographs are given of ingots 2 and 4 tons weight, cast first without a sinking head and without after-pouring; next cast with a sink-head; next cast with a sink-head and with arrangements for keeping the sink-head hot while setting. All these showed progressive improvement, with successively larger proportions of the ingot sound and fit for use. Tests were then made with sink-heads, kept hot, and using in them so called "sink-head thermite," contained in a box fastened tightly to an iron rod so as to be sunk 80 centimeters or deeper into the fluid steel. Immediately on introducing the thermit charge (consisting of iron oxide and aluminium powder) the reaction commences and is completed in 5 to 10 seconds, causing strong boiling up of the steel and bringing slag up to the surface plentifully. The slag is lifted off with a scraper, and more fluid steel poured in. The thermit box was 12 centimeters long by 10 centimeters diameter; cost, full of 1.3 kg. of mixture, $0.93, and sufficed for treating a 1-ton ingot. The Goldschmidt Thermit Co. puts up boxes marked 0, 1, 2, 3 and 4, holding, respectively, 1.3, 2.5, 5, 7.5 and 10 kilos of thermit mixture, and suitable for treating ingots of 0.5 to 1, 1 to 2.5, 10 and 15 tons weight, respectively. By this treatment, ingots which are to be rolled or forged can be made entirely free from sink-head cavities. For best results, the sink-head should be one-fourth the height of the clean part of the ingot, and is partly filled with a lining of stamped-in poorly-conducting moulding sand, in order to reduce the radiation and keep the sink-head fluid. The opening on top need only be 20 to 30 centimeters across, so as to reduce radiation therefrom. Numerous analyses are further given of ingots cast without and others cast with thermit treatment, showing slightly less segregation in the latter case.

Determination of Chromium.—G. von Knorre, in *Stahl und Eisen* of Aug. 28, gives his most recent methods for determining chromium in steel, especially in presence of tungsten. In 1903, the author showed that persulphates convert chromic salts easily into chromic acid, and if the excess of persulphate is then destroyed by long boiling the chromic acid can be determined according to known methods, such as by adding a measured quantity, in excess, of standardized ferrous sulphate solution acidulated with sulphuric acid, and determining the unused ferrous salt by permanganate

$$6FeSO_4 + 2CrO_3 + 6H_2SO_4 = 3Fe_2(SO_4)_3 + Cr_2(SO_4)_3 + 6H_2O$$

Ferric salts and copper salts do not interfere. Manganese can be simultaneously determined, as Ibbotson, Howden, Walters and Kleine have shown.

In steels not containing tungsten the chromium is determined without removing iron, as follows. The quantity taken is graded according to the chromium present, with small chromium content (less than 0.5 per cent.), 6 to 10 grams; from 0.5 to 2 or 3 per cent., 1.5 to 6 grams, with high chromium steels or ferro-chrome, 1 gram or less. If it is not known approximately how much is present use 3 to 6 grams. With less than 2 per cent of chromium present 20 per cent sulphuric acid, cool at first and finally brought to boiling, brings all the chromium into solution, with 2 to 3 per cent chromium longer boiling also takes up the chromium. A 14 per cent chromium alloy must be dissolved, however, in 50 per cent sulphuric acid. Nother found this acid to dissolve completely, by long boiling, all the chromium in a 33 per cent alloy. After solution, the excess of free acid is neutralized by ammonia, caustic potash

or caustic soda, and then the solution of ammonium persulphate, 120 grams to the liter, is added in small portions until the ferrous salt present is entirely oxidized, as is determined by dropping in ammonia and seeing the brown ferric hydroxide; then an excess of 25 to 40 c.c. of persulphate solution is added. If it is desired to economize persulphate, the iron can be oxidized by nitric acid, which is added in small quantity to the original acid solution and heated to boiling; the free acid is then neutralized and some 40 c.c. of persulphate solution added. In either case, after the persulphate is added the solution is diluted to 400 or 500 c.c., 20 c.c. of dilute sulphuric acid, sp. gr. 1.10-1.18, added, and boiled 20 to 30 minutes. If manganese is present it separates out as hydrated manganese dioxide, which can be filtered out and the manganese determined in it; the chromium is now determined in the filtrate. Manganese only precipitates thus after the complete oxidation of the chromium to chromic acid. If no manganese is present it is advisable to boil only 10 minutes, cool, add more persulphate and boil again 20 minutes. The acidulated ferrous sulphate solution of known titrated strength is then added until the solution is green, the whole left 1 hour on the water bath, then the solution, strongly diluted, and the ferrous salt remaining titrated by permanganate solution, a fractional part of the main solution being used. Every three atoms of ferrous iron disappearing corresponds to one atom of chromium present as chromic oxide. The ratio is Cr = 0.3109 iron. It is of first importance that all persulphate shall have been removed by the half-hour boiling, else the titration will not be accurate.

In steels containing tungsten, the latter remains insoluble in sulphuric acid as a black powder. On oxidizing with nitric acid or persulphate some tungsten goes into solution, but most remains as hydrated tungstic oxide, which should be filtered out if in large quantity. To avoid this filtration, which goes slowly, there may be added sodium phosphate solution, which makes with the tungsten soluble sodium phospho-tungstate, which is not decomposed by mineral acids; enough concentrated caustic alkali solution is then added to make the solution strongly alkaline; sulphuric acid is then slowly added until the iron precipitate is entirely dissolved. Persulphate solution is then added, and the analysis finished as before, except that manganese is not simultaneously determined, because of the presence of phosphoric acid. High tungsten steels are not entirely dissolved by sulphuric acid, but are best boiled first with 50 per cent sulphuric acid until no trace of hydrogen is escaping, then nitric acid, sp. gr. 1.2, added in small quantities and the solution boiled a few minutes until the metallic tungsten is entirely oxidized to yellowish tungstic hydrate.

Tests on chromium steels, tungsten absent, showed results within 0.06 per cent in the extreme case of 14.60 per cent of chromium present; and a similar accuracy in steels with up to 5 per cent chromium and as much as 25 per cent tungsten.

Fuels.

Water Gas.—Director H. Dicke, of Frankfurt, gives in *Stahl und Eisen* for Aug. 14 and 21, a concise and useful review of the history of water gas and its present metallurgical uses. He recalls that in 1880 the Europaiska Wattergas Actie-Bolaget, of Stockholm, first introduced the American Lowe generator into Europe, and that next the sheet-iron works of Schulz-Knaudt, in Essen, put in a plant, using the gas for welding shafts. The latter plant was entirely rebuilt by E. Blass, in order to better adapt it to German conditions. In 1885, Mr. Blass reviewed the condition of the water gas industry (*Stahl und Eisen*, 1886, p. 3), showing that ordinarily 60 per cent of the fuel was used during "heating up," in making producer gas, and only 40 per cent was used when "cooling down," in making water gas; the water gas had about one-half of the calorific power of the fuel from which it was made. The Dellwik-Fleischer system changed all that; instead of blowing air 7 to 12 minutes for heating up and then steam for 6 minutes, cooling down, it was found practicable, with a very strong air blast, to run on air only 1 to 2 minutes, followed by steam 5 to 7 minutes. The very high velocity of the air blast prevented formation of producer gas, and burns the fuel which is oxidized entirely to CO^2, giving no producer gas as a by-product, and utilizing up to 75 per cent of the fuel for water gas instead of 40 per cent. This doubling of the efficiency of water gas production resulted in a rapid introduction of the system into many industries. For many years H. Dicke was the chief engineer of the Wassergas-Syndicats System Dellwik-Fleischer in Frankfurt.

Engineer Dicke then describes at length the construction and operation of the system, the details of which are unnecessary to repeat. In an hour the new producers are making water gas 50 minutes, while only 10 minutes altogether are used in heating up and changing connections. One man can attend a generator producing 1,000 cubic meters (35,000 cubic feet) of water gas per hour. The average analysis of practically made gas is given as

	Per Cent.
Hydrogen	49
Carbon monoxide	39
Carbon dioxide	5
Methane	0.7
Nitrogen	6.3

The rest of the first article is concerned with the detailed costs of welding iron and steel by use of coke, acetylene and water gas; showing that the cost of fuel is only half as much as using coke fire direct, and that the output is increased 80 per cent for the same labor costs.

In the second part, Dicke takes up the use of water gas in open-hearth furnaces, for gas engines and for lighting. In Siemen's furnaces it is unnecessary to preheat the gas, requiring, therefore, only a single regenerator at each end of the furnace and a single pair of reversing valves. Even with this, higher temperatures and quicker melting can be obtained than with preheated producer gas. The attempt to use water gas mixed with producer gas in open-hearth furnaces was not satisfactory in Germany, and water gas is used alone. Nydquist and Holm, in Trollhätten, Sweden, erected early in 1906 two open-hearth furnaces of 5 and 8 tons capacity, run only on water gas, with most satisfactory results as to the quality of the steel. This so-called "water-gas steel" is sold as the finest quality of open-hearth steel, but costs no more than that made with ordinary producer gas. The same firm uses water gas in a regenerative crucible steel furnace, in which 10 crucibles are placed, each with 30 kilograms of charge, and melted down in 3½ hours, with a fuel consumption of 270 kilograms of fuel, including that used for raising steam for the producer. The temperature in the furnace is, by Seger cone, 1,840° C.

Small gas engines run very successfully on water gas. A 30-hp. engine of the Augsburg-Nurnberg make uses 0.86 cubic meters of gas per effective horsepower-hour. The gas having a calorific power of 2,450 Calories per cubic meter, this corresponds to 2,100 Calories furnished per effective horsepower-hour. This would correspond to only 2,800 Calories calorific power of the fuel used, or some 0.35 kilogram (0.75 pound) per effective horsepower-hour. With pure water gas, of above calorific power, it is not practicable to use it in engines over 50 hp., but gas of lower calorific power per cubic meter can easily be made by mixing the gas of the heating up period with the water gas, so as to make a gas with a calorific power as low as 1,100 Calories per cubic meter of the following composition:

	Per Cent.
Hydrogen	19
Carbon monoxide	21
Carbon dioxide	11
Methane	0.3
Nitrogen	48.7

One metric ton of coke will make 5,200 cubic meters of this gas, which will give one effective horsepower for each 0.4 kg. of coke used per hour, or adding in 0.1 kg. of coke for steam, 0.5 kg. (1.1 pounds) altogether. This gas can be used in gas engines of any size, and the calculation is made that in Germany (paying the head engineer, for instance, $1.10 per day, and his assistant $0.60) the total cost will be 3.64 pfennigs (0.9 cents) per effective horsepower-hour. By a recent patented process, Dr. Fleischer has succeeded in making a clean gas for power purposes from ordinary gas coal, avoiding altogether the presence of distilled tar in the gas. Altogether, fifty-four works are using at present eighty-seven water-gas plants on the Dellwik-Fleischer system for power purposes.

Illuminating gas is made much cheaper by this system than by any other; water gas is particularly suitable for use with the Welsbach mantle. One candle power will be given by an hourly consumption of 1.6 liters of water gas in a mantle, against 1.35 liters of distilled coal gas, but the former uses 4 Calories against the latter 4 Calories for the same amount of light. This difference is ascribable to the greater velocity of propogation of flame (ignition velocity) of water gas, giving a shorter but more intense flame. Many old gas plants use a supplementary water-gas plant, and mix water gas with their coal gas, thus utilizing their old plants and avoiding the benzol carburetting operation, by passing the water gas through the gas retorts during the distillation of the gas coal—the so-called "auto-carburetting" operation. The presence of the water gas in the retort during the early part of the distillation, in the first 2 hours, during which the high illuminants are escaping, largely prevents the splitting up of the latter and the deposition of retort carbon. It also facilitates the distillation process. The advantages of this auto-carburetting operation are so great that in a relatively short time the "Deutscher Wasser-gas-Beleuchtungs-Gesellschaft," in Berlin, has equipped twenty-four cities with this combination plant. The saving in benzol alone has reached $12,000 to $19,000 per year in the plant of a moderate sized city, paying for the cost of the Dellwik-Fleischer plant by this saving in less than eighteen months. This gas is so well suited for Welsbach burners that Dicke thinks it a matter of only a short time when the universal method of making illuminating gas will be: Distillation in retorts; use of part of the coke for firing the retorts; use of the rest of the coke in Dellwik-Fleischer water-gas plant; auto-carburization by passing the water gas through the distillation retorts. This mixed gas will have a calorific power of about 3,800 Calories per cubic meter, and cost only 0.37 cent per cubic meter (11 cents per 1,000 cubic feet).

TIN.

Detinning.—In *L'Industrie Electrique* of Oct. 25, a method of Theirot and Nougier is described for winning tin from tin scrap or from various tin residues. The process is said to have been in satisfactory commercial poeration for several years. The first step consists in the production of a solution of sodium stannate. This is then purified to remove especially copper and lead. Finally the pure sodium stannate solution is electrolyzed between iron anodes and tin cathodes. A solid adherent deposit of tin is obtained if the temperature is held as nearly as possible at 80° to 90° C., with a current density of 300 or 400 amps. per square meter (one side of the cathode only being counted). It is also necessary to maintain the solution sufficiently concentrated with sodium stannate and to submit it to strong circulation. Each bath absorbs 2.4 volts.

MISCELLANEOUS.

Synthesis of Precious Stones.—A paper presented by F. Bordas before the French Academy and printed in *Comptes Rendus* of Oct. 28, refers to the occurrence of corundum in nature in various colors. The different colors of the sapphires are generally attributed to the presence of impurities like chromium, cobalt, etc. Bordas, however, thinks that this is not true, since he could vary the color of the stones at will by submitting them to the action of radioactivity. When a bluish sapphire was subjected to the action of radium bromide, the color passed first into green, which then changed to a bright yellow and finally became dark yellow. When a red ruby was treated in the same way the color changed to violet, blue, green and yellow. The author proposes the hypothesis that precious stones of this kind found in nature occur in regions where the surrounding soil is radioactive, and that for this reason the yellow sapphires (being the final product) are the commonest.

Titanium in Steel Metallurgy.

Mr. CHARLES V. SLOCUM recently delivered a suggestive address on the applications of titanium before the Pittsburgh Foundrymen's Association. He mentioned some cases where unusual wearing qualities of car wheels were traced to the presence of titanium in the iron.

In 1895, Mr. Auguste J. Rossi smelted for the New York Car Wheel Works several hundred tons of ore high in titanium in a small blast furnace with a capacity of 3 to 4 tons per day. The iron obtained was a remarkably strong gray pig, and the object of the experiment was attained, namely, to show that titaniferous ores can be readily smelted in the ordinary way, if given proper attention and proper flux. Later on experiments were made by Mr. Rossi on the production of ferro-titanium in the electric furnace. These were described by Mr. Rossi himself in detail in our Vol. I., page 523.

The addition of ferro-titanium to steel materially increases the breaking strength. One reason why titanium is so effective in steel is that it eagerly combines with any nitrogen in the molten metal and thereby prevents the formation of blowholes.

Titanium is now also used as an addition in flame car lamp electrodes. Concerning Mr. Rossi, as the pioneer of titanium, himself, Mr. Slocum made the following remarks:

"Auguste J. Rossi is a Frenchman by birth. He was born in Paris in the last century, which, as he humorously expresses it, 'sounds well and is near enough.' He carried on his early studies at home and at the University of France, from which he graduated at the early age of 16 years and one month with the degrees of Bachelor of Science and Master of Arts. He then entered the Ecole Centrale of Arts and Manufactures and graduated three years later as civil and mining engineer at about 19½ years of age, having thus obtained four university degrees at an age when most young men are about entering college. Almost immediately afterward he came to this country, and was for twelve years technically in charge of the Boonton Iron Works of New Jersey. It was during this period that titanium seems to have attracted his attention, for during the past thirty years he has devoted much of his time and a great deal of labor and money to its study and the development of methods for its use, and has taken out many patents in relation to them. The most gratifying results have been obtained by the aid of the electric furnace. "Although a man well advanced in years, he is much pleased to have received from all parts of the world congratulations on the final success of a life of faithful, well-directed effort. It is not too much to believe that future generations will be proud to claim Auguste J. Rossi as one of America's adopted sons who has benefited the entire civilized world."

We have already noted that the ferrotitanium industry is now about to enter the commercial stage, and hope to publish more exact information on this interesting development in steel metallurgy in the near future

Standardization.

The Institution of Mining and Metallurgy (London) has sent out an official announcement stating that the following definitions have been adopted by the institution:

(1) The word "ton" shall represent a weight of 2,000 pounds avoirdupois (=29,166.6 ounces troy). It is advisable to abandon the use of the terms hundredweights and quarters, and to express fractions of a ton in pounds or in decimals of a ton.

(2) The term "miners' inch" shall represent a flow of 1.5 cubic feet of water per minute; and the term "sluice head" shall represent a flow of 60 cubic feet of water per minute. It is advisable, however, to abandon the use of both terms, as being merely of local usage, in favor of definite expressions of the flow of water per minute, or per second, in cubic feet or in gallons.

(3) The word "gallon" shall represent the imperial gallon measure of 10 pounds of water.

(4) Temperatures shall be expressed in degrees centigrade.

(5) Returns of gold and silver shall be expressed in terms of fine gold and fine silver, respectively, not as "bullion."

(6) Gold contents of ores, etc., *determined by assay*, shall be expressed in money values as well as in weights; and in this connection the value shall be taken (as a convenient constant) at 85 shillings, or $20.67 United States currency, per troy ounce of fine gold.

Mesh of Wire Cloth.—The following table of "I. M. M. Standard Laboratory Screens" is intended for use in making grading tests and for the correlation of screens used in commercial or other work. When screens other than the I. M. M. standards are employed, the diameters of apertures should be given in any published results, so that comparisons may be made. When screens are described simply by the number of meshes per linear inch, it will be understood that the I. M. M. standard is referred to. The number of sizes standardized has been reduced to a minimum, as it is desirable to abandon excessive refinements in grading tests. It is believed that the I. M. M. standards will meet all necessary requirements of the laboratory. In reporting grading tests it is desirable to state whether wet or dry screening has been employed.

Table I. M. M. Standard Laboratory Screens.

Mesh or Apertures per Linear Inch.	*Diameter of Wire.*		*Aperture.*		*Screening Area.*
	Inch.	*MM.*	*Inch.*	*MM.*	*Per Cent.*
5	0.1	2.540	0.1	2.540	25.00
8	0.063	1.600	0.062	1.574	24.60
10	0.05	1.270	0.05	1.270	25.00
12	0.0417	1.059	0.0416	1.056	24.02
16	0.0313	0.795	0.0312	0.792	24.02
20	0.025	0.635	0.025	0.635	25.00
30	0.0167	0.424	0.0166	0.421	24.80
40	0.0125	0.317	0.0125	0.317	25.00
50	0.01	0.254	0.01	0.254	25.00
60	0.0083	0.211	0.0083	0.211	24.80
70	0.0071	0.180	0.0071	0.180	24.70
80	0.0063	0.160	0.0052	0.157	24.60
90	0.0055	0.139	0.0055	0.139	24.50
100	0.005	0.127	0.005	0.127	25.00
120	0.0041	0.104	0.0042	0.107	25.40
150	0.0033	0.084	0.0033	0.084	24.50
200	0.0025	0.063	0.0025	0.063	25.00

Whilst absolute accuracy to the fourth place of decimals of an inch is impracticable in the manufacture of wire cloth, a sufficiently close approximation to the above standards is attainable.

The adoption of a screening area of 25 per cent. necessitating equality of size of wire and aperture, secures perfect interlocking and consequent permanence of aperture.

Some of the finer mesh screens can only be woven in what is known as "twilled."

Ferro-Alloys in the Foundry.

An interesting paper on special ferro-alloys for the foundry was recently presented by Mr. E. Houghton, of Chesterfield, before the British Foundrymen's Association.

After having briefly sketched the development of the ferro-alloy industry, the author remarked that until recently its importance has been confined more or less completely to the steel works, including steel foundries, but now, quite a number of people are experimenting with ferro-alloys in ordinary iron founding, and, as the alloys become better known to foundrymen, it is not unreasonable to expect that they may play an important part in the foundry practice of the future. The object of their use in the foundry is of two kinds:

(1) To act as deoxidizers and desulphurizers, the added element remaining only in small quantities in the finished casting.

(2) To alter the composition of the casting and so to gain control of the condition of the carbon and the mechanical properties of the casting.

Ferro-Manganese and Spiegeleisen.—Compared with the old blast-furnace alloy, the characteristic features of the electric-furnace alloy are a much smaller amount of carbon, and, if desired, a higher percentage of manganese. Mr. Houghton remarks that from the foundryman's point of view it will always be best to use the rich alloys (or metallic manganese) rather than the lower grades, as by this means the alloy can be added solid to the ladle without unduly cooling it. If the very low grades are used it becomes necessary to melt them either separately prior to addition or along with the charge.

Mr. Houghton believes the latter plan is adopted in making chilled rolls in certain works where manganese is used to influence the chilling properties. But it is a question whether in this case the chill is all that can be desired, as a chill due to manganese is apt to show a sharp line of demarcation between the chilled part and the grey body of the casting, whereas a chill due to carbon alone should extend with roots into the casting.

Mr. Houghton's own conclusion in regard to the addition of alloys in general to cast iron is that much greater benefit will be secured by addition after melting, as will be mentioned below in connection with ferrosilicon.

In a paper which Mr. Houghton read at last year's convention, it was pointed out that use could be made of ferro-manganese in the removal of sulphur from common irons, and several instances were quoted in support of the statement. This, of course, can only occur where the pig iron is bad to start with, and must not be taken as an unqualified assertion that ferro-manganese added to any iron will improve it. It might do just the reverse in some cases. Excess of manganese hardens cast iron, the limit being about 1.25 to 1.75 per cent.

A considerable reduction in the sulphur content of iron melted in the air furnace could readily be brought about by addition of ferro-manganese to the molten metal in the furnace, and this without seriously increasing the manganese content of the final casting.

Moreover, at high temperatures manganese is readily oxidizable, and will rob iron of oxygen taken up as oxide in melting, although it is not so efficient in this respect as some of the alloys to be mentioned later. At the temperature of molten steel this property is very strong, but at the lower temperatures of molten cast iron it is less active. The presence of oxide of iron in cast iron is responsible in many cases for blame put on other things, and the good effects obtained by the use of special alloys are due, in many cases, solely to the removal of this oxygen from the metal.

Ferro-manganese is used by some carwheel makers, where it is thrown as a fine powder (about 1 pound to 300

pounds) into the bottom of the ladle before tapping. It is said that this permits of a much larger proportion of scrap being used along with poorer grades of pig iron, and that the depth of a chill can be regulated by varying the amount added.

It may, of course, be argued that where additions to pig-iron are necessary in iron foundry practice they may be obtained at less cost by the purchase of suitable pig iron rich in the desired element, and no doubt there is something in this where there is sufficient chemical control to enable it to be carried out. Mr. Houghton is inclined to think, however, that many foundrymen would prefer to retain those mixings with which they have become familiar, and make any alterations they wish by means of an alloy rich in the desired element; the other constituents then remain unaltered, or nearly so. In any case, it would seem that additions made after melting the iron are most effective, and, after all, that is the point.

Silicon Spiegel.—The chief characteristic of blast-furnace silicon-spiegel is the high manganese and silicon (in the analysis given from 17 to 21 per cent Mn and from 9 to 15 Si), together with remarkably low total carbon (1 to 2 per cent), and it is interesting to note that when the silicon is under 10 per cent the carbon becomes more and more graphite. The electric-furnace products are, however, lower still in carbon.

Silicon-spiegel is used in steel foundry practice to prevent honey-combing, the silicon increasing the solubility of gases in the metal when solidifying, and the manganese removing oxygen from the iron and becoming oxidized itself.

A similar action should take place when the alloy is added to molten cast iron, particularly if melted in an air furnace, where higher temperatures can be attained than in the cupola.

The silicon should also have a softening effect on cast iron, which would be still further enhanced by the manganese accompanying it if the iron were previously too high in sulphur.

It seems as though there should be a use for this alloy in the iron foundry, as both manganese and silicon are deoxidizers of considerable power.

Ferro-silicon.—Ferro-silicon is now used very considerably in the foundry. Mr. Houghton refers to Mr. A. E. Outerbridge's well-known experiments. With ferro-silicon added in the ladle these experiments show gains "in transverse strength and deflection of as much as 24 per cent and 30 per cent respectively," and if this can be obtained regularly it is worth trying for. Mr. Outerbridge is, however, careful to point out that the silicon is much more effective when added in the ladle than when added in similar quantity to the mixture on the cupola stage, the chief benefit derived from its use being the deoxidization of the metal by removal of the oxygen taken up from the blast.

There is another very useful feature of silicon, and that is its well-known influence on the carbon contents, tending to convert it to the graphitic condition, and so produce a soft casting. For this purpose, there is no doubt silicon can, as a rule, be added to the charge without any additional expense by the use of glazed iron, but one needs to be careful that it is glazed foundry, not glazed forge iron; the latter is high in sulphur, and no good for softening purposes. This method, however, results in a more or less fixed product, and if the class of work requires considerable variation in the silicon content on the same day, it is at best a clumsy and indeterminate method.

On the other hand, by the addition of ferro-silicon, the silicon content of each ladle can be altered at will to suit the particular castings it is designed for.

Ferro-chrome.—If chromium is to be used at all in the foundry it will have to be used sparingly and for particular work only, mainly on account of its cost.

Since chromium converts carbon to the combined form, it is a hardener, whilst, generally speaking, in the foundry we are more concerned to find softeners. The writer has, however, lately heard of the use of chromium in the production of castings in which hard wearing properties are extremely desirable, and cost is somewhat secondary, as, for example, in cast-iron piston rings.

Ferro-Phosphorus.—Ferro-phosphorus is chiefly used to enrich the phosphorus in the slag from basic steel furnaces, so as to make it a saleable commodity.

The only possible use for such an alloy in the iron foundry would be in the production of very fine and thin castings, artistic work where excellency of detail was of permanent importance and strength secondary. From 2 to 5 per cent phosphorus, according to Prof. Turner, makes the metal very fluid when molten, and causes it to take an excellent impression of the mould.

Such castings are very brittle, but they have to be made sometimes, and, although phosphorus is an element one generally does not expect to have to pay for, but rather to claim something back for, still it may be there is a use for such an alloy in the foundry on work which is only very occasional.

Ferro-titanium.—Titanium combines eagerly with nitrogen as well as with oxygen. To obtain perfectly sound castings it is important to remove all gases. Consequently an element which combines both with oxygen and nitrogen should be very beneficial in this respect.

It seems probable that combined nitrogen plays a very important part in reducing the strength of cast iron, and if so it will be convenient to have an antidote so handy. Titanium is said to increase both the transverse strength and the hardness of the chill of cast iron.

Ferro-aluminium.—This is used almost solely as a deoxidizer, and it is very efficient in this role, but it is undesirable that much of it should remain in the metal. The chief drawback to the use of aluminium for this purpose is that solid alumina is produced which is apt to remain suspended in the metal, and this causes lack of continuity of the metallic structure and loss of strength sometimes.

There has consequently been a tendency to introduce mixed alloys. Of these, Mr. Houghton mentions ferro-aluminium-silicide, ferro-calcium-silicide, which is a very powerful deoxidizer, and ferro-manganese-aluminium silicide, "which should be a very useful alloy for foundry purposes." The full paper which is printed in *The Iron and Coal Trades Review* (London) of Sept. 20, contains various analysis of commercial ferro-alloys, both blast-furnace alloys and electric-furnace alloys.

Aluminium Price Reduction.

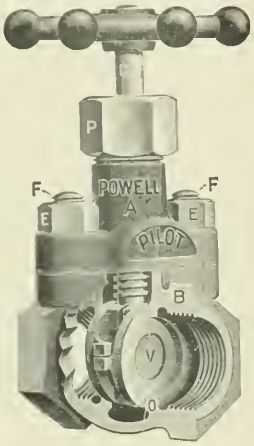
From Europe come reports of a considerable reduction of price in aluminium.

The London *Electrical Review* writes as follows: "For the moment the matter apparently mainly affects the continent of Europe, where conflicting reports are in circulation. On the one hand, it is stated that the price was reduced on Oct. 1 from 3s. to 2s. per kilogramme, or by 33 1/3 per cent, whilst on the other, it is declared that large contracts are still being booked at 2s. 9 1/2d. per kilogramme. It appears, however, the real fact is that the principal producers have decided to lower the charge from 3s. to 2s., as from Jan. 1, 1908. No doubt the impending diminution, apart from the expanding output of aluminium, is prompted by the fall in the price of copper, as the former metal is becoming increasingly employed as a conductor as a substitute for copper in electrical work."

We may add that undoubtedly the erection of new aluminium plants in various European countries where the process is no longer protected by patents, has much to do with this reduction in price.

Valve.

The "Pilot" iron body gate valve is another addition to the already long list of steam specialties manufactured by the William Powell Company, of Cincinnati. The adjoining illustration shows a strong, compactly built valve with every detail carefully worked out. The iron body is built for service and is designed with heavy lugs on either side of the neck, carrying stud bolts F. The bonnet cap A has corresponding lugs drilled to template, which insures a perfect joint and constant alignment at all times, and also allows the bonnet to be replaced without unusual care after taking apart for inspection or repairs. Two semi-finished hexagon nuts E large enough to admit wrenching down hard, with a joint of the best packing material between the faces of bonnet and body, made an absolutely tight joint for all pressures up to 100 pounds. The large brass packing nut P should be noted affording plenty of room for packing material, to prevent leakage around the stem.



VALVE.

The brass stem D and bonnet are chased and cut to a true acme thread of unusual length, the best for wear. The length of thread keeps the stem in a true axial position at all times whether open or closed. The knobby hand-wheel gives a firm grip, even though the hands may be oily.

The discs are double, not a single wedge, with ball and socket back, making them adjustable. They are hung in recesses to the collar on the bottom of the stem. The discs, working in a tapering seat, expand or collapse in opening or closing, making a valve that will close down tight without straining or open easily, no matter what the conditions may be.

The Powell Pilot gate valve is also made all of iron, that is, discs, stem and packing nut are of iron; not a particle of brass used in its construction anywhere. This all-iron pilot gate valve will be found especially valuable in controlling ammonia, cyanide solutions, acids and all other liquids or gases that attack brass.

The Floating Battery of the Cambria Steel Co.

While the introduction of electric power for all purposes has revolutionized to a large extent the operation in modern iron and steel plants, the economies which may be obtained by the use of a storage battery are not yet fully appreciated. For this reason the following notes, taken from a recent pamphlet of the General Storage Battery Co., of New York, should be interesting.

There are many plants in which a large part of the electric power load is at a considerable distance from the generating station, where the installation of a suitable storage battery, floating on the line at or near the local center of distribution of the distant load, will produce excellent results. By increasing the load factor (that is the figure which indicates to what extent the maximum capacity of the plant is utilized in average operation) it will effect a great saving in plant operation. It will also maintain an increased and steady voltage at the load, and increase the plant output at far less cost than would be necessary for an increase in the generating equipment.

The Cambria Steel Co. uses two large ore bridges and one car dumper, all operated by electric motors and supplied with current by a set of feeders from the main power house, the center of the load being approximately 3,000 feet from the power house.

The work of these motors is of necessity heavy and intermittent, so that the resultant load on the power house fluctuates widely. The momentary current values vary from 400 to 4,000 amps., equivalent to rapid fluctuations in load from 100 to 1,000 kw. at 250 volts.

Prior to the installation of the storage battery, twelve 500,000 C.M. cables were used as feeders (six outgoing and six returning), to supply the motors operating the ore bridges and car dumper. The voltage at the center of the motor load, at the same time, fluctuated through wide limits.

To meet the demands for an increase in load, it was found necessary either to increase the generating plant or relieve it of power fluctuations to such an extent that additional load could be handled by the existing units.

It was found, as is usually the case, that the installation of a storage battery near the center of load could be made at much less cost than an increase in generating equipment, and would have the additional advantage of increasing the load factor of the plant, with consequent more economical operation. Besides this the voltage at the center of load could be maintained at a higher working value, and the battery could be used in emergencies as a reserve.

Calculation showed, also, that the feeder copper which could actually be removed, following the installation of a battery at the center of the load, would go a long way toward paying for the battery.

To attain these advantages it was necessary, however, that the storage battery installed should go from charge to discharge, with small changes in voltage at its terminals; should be capable of being operated with little or no attention; should be able to withstand occasional overloads without detriment; and, in emergency, be able to stand fully discharged for short periods, without permanent injury.

As the construction of the Bijur "High-Duty" batteries (an illustrated description of which may be found on page 203 of our Vol. III.) lends itself admirably to these requirements, it was decided to install a battery of this type. It consists of 106 cells of the General Storage Battery Co.'s regular Bijur "High-Duty" type, having a capacity of 2,400 amps. for 20 minutes.

Each cell has twenty-five plates, approximately 15½ x 15½. The plates are burned to bus-bars of rolled lead, except in the terminal cells, where the bus-bars are provided with internal copper conducting reinforcements. The connections between adjacent rows of cells are made by means of lead-covered copper bar.

The lead-lined containing tanks are sufficient in size for thirty-one plate elements, providing for future increase in the capacity of the battery.

Each tank is provided with double insulation, the glass insulators supporting the wood stringers resting on vitrified tiles set in the concrete floor of the battery room.

The battery house is of brick, with slate roof and concrete floors; the building is well lighted and is provided with drains, so that the entire battery room may be flushed out. A separate room is provided in the building for the battery switchboard.

The switchboard in the battery sub-station is provided with a distant control circuit breaker which may be opened or closed by hand at the battery house, or electrically from the power station. The arrangement is such that opening of the circuit breaker is immediately signaled in the power station, and this breaker can be closed from the power station by the switchboard attendant.

Owing to the distance (3,000 feet) between the battery and

power station, it was found that comparatively small changes in current over the feeders to the battery would produce sufficient change of voltage at its terminals (due to feeder drop) to cause it to go from full charge to full discharge; in fact, the battery so situated removes the fluctuations from the power station to such an extent that it was not considered worth while to install a regulating booster at the power station.

By the selection of the proper number of cells, the battery has been arranged so that while merely floating on the line, its total charge and total discharge over an extended period are equal, hence the state of charge of the battery remains substantially constant.

In order, however, to provide for an increase in the condition of charge, and to give occasional overcharges, required for best operation, a separately excited motor-driven booster is installed in the power station. Provision is made for connecting the booster armature in series with the battery feeders, between them and the station bus-bars, the voltage then being raised by hand regulation to the extent desired to overcharge the battery. This overcharging with the hand regulated booster is usually done at times when the ore bridges and car dumper are not in operation, although it may be done at any time.

The construction of the battery plates in this installation is one offering the greatest freedom to diffusion of the electrolyte. The cells can be charged completely full with less than 2½ volts each, at the normal 8-hour rate. This feature ensures charge and discharge taking place with minimum changes from an average floating voltage; a feature affording high working efficiency.

The plates are also free from mechanical disturbances of any kind, so that in practice the battery house is left entirely without attendance for a week or more at a time, the only attention required being the occasional replenishing of the cells with water to provide for evaporation and general inspection of the battery. Emergencies in which the battery has been compelled to remain without attention for protracted periods, and in which its reserve function has been called upon to its fullest extent have been met, without any detrimental effect whatsoever.

Summarized, the results which have been attained by the Cambria Steel Co. from this installation are as follows:

(1) Saving in initial cost over generating equipment of equivalent capacity.

(2) Saving of 27,700 pounds of copper removed from the feeders.

(3) Removal of fluctuations from the power station.

(4) Increase in the working voltage.

(5) Reduction of feeder losses.

(6) Increase of station output from existing units.

(7) Creation of a reserve source of supply.

Notes.

American Electrochemical Society.—At the meeting of the board of directors, held at New York City, Oct. 17, the following gentlemen were elected members of the American Electrochemical Society: Dexter G. Giles, manager, Elmira Machine Works, Elmira, N. Y.; Louis I. Waldman, president, Hudson River Aniline Color Works, Albany, N. Y.; Louis V. Emanuel, American Smelting & Refining Co., Maurer, N. J.; John Gaub, New Jersey Agricultural Experiment Station, New Brunswick, N. J.; Noel Statham, West Virginia Pulp & Paper Co., New York City; Federico Giolitti Ph. D., professor of metallurgy, University of Rome, Rome, Italy; Richard H. Gaines, chemist New York Board of Water Supply, New York City; Edwin F. Northrup, The Leeds & Northrup Co., Wayne Junction, Philadelphia, Pa. At the meeting of the board, held in Philadelphia on Nov. 26, the following gentlemen were elected members: Howard D. Smith, Ph. D., Beloit College, Beloit, Wis.; William H. Bassett, chemist, the American Brass Co., Waterbury, Conn.; H. Clyde Snook, A. M., president, Roentgen Manufacturing Co., Philadelphia, Pa.; John Clement Bradley, assistant chemist, the American Brass Co., Waterbury, Conn.; F. Fichter, Ph. D., professor of organic chemistry, University of Basel, Basel, Switzerland; William C. Geer, chief chemist, the B. F. Goodrich Co., Akron, Ohio; Dr. Georg Langbein, Hofrath, manager, Langbein Pfanhauser-Werke-A. G., Leipzig, Germany; Axel O. Appelberg, Ph. D., research chemist, General Electric Co., Schenectady, N. Y.; Colin G. Fink, Ph. D., research chemist, General Electric Co., Schenectady, N. Y.; Charles F. McKenna, Ph. D., chemical engineer, New York City.

American Foundrymen's Association.—At a meeting of the executive board it was decided to hold the next convention at Toronto, Ont., the time to be the first week in June as usual.

Niagara Falls of To-day.—The Board of Trade of Niagara Falls, N. Y., has recently issued an illustrated pamphlet, with numerous illustrations, giving outside views of many of the principal industrial plants located there. A map of Niagara Falls shows in red the lands controlled by the different power companies for the location of industries.

Oil Refinery.—The October issue of *The Outlook* contains a well-written article of a popular nature on the industrial system of the Standard Oil Company, by Harold J. Howland.

Tungsten.—The Atolia Mining Co., of San Francisco, operating the Randsburg (California) Tungsten mines, which have in the past been one of the largest American producers of Tungsten ores, have closed down their mines indefinitely.

Alundum as Abrasive.—The Norton Co., of Worcester, Mass., have recently issued an interesting and nicely illustrated pamphlet on alundum, its invention and use. Alundum is purified bauxite. The bauxite from the Norton Co.'s own mines is heated in calciners to drive off the combined water, and is then melted in electric furnaces at a temperature of 5,000° to 6,000° F. The electric-furnace plant is located at Niagara Falls. The electric furnace treatment insures the purity and uniformity of the alundum. The alundum is worked up into grinding wheels, rubbing and sharpening stones in the Worcester plant. The chief claims made for alundum as an abrasive are great sharpness, great hardness, right "temper" (*i. e.*, strength of grain and character of its fracture under grinding pressure) and absolute uniformity.

Internal Combustion Engines.—The November issue of *Cassier's Magazine* is entirely devoted to internal combustion engines. After an historic review of the subject by H. H. Suplee, the practice of construction of large gas engines in America, England and Germany is discussed by E. T. Adams, W. H. Booth and F. E. Junge, respectively. There are also articles on the utilization of blast furnace gases, by B. H. Thwaite and Leon Gremer, on the use of low-grade fuels in the gas producer, by C. T. Wilkinson; on gas-power applications, by J. R. Bibbons, on the by-product gas producers, by H. A. Humphrey, on the use of bituminous coal in the gas producer, by E. A. Harvey, on the suction gas producer, by F. J. Rowan and J. M. Hart, and other articles and notes.

Production of Gold and Silver.—Figures have just been published by the Bureau of the Mint and the United States Geological Survey on the production of gold and silver in the United States in 1906. The total production of gold was 4,565,333 fine ounces, valued at $94,373,800, an increase of 299,591 ounces over 1905. The largest increase was in Alaska (increase 311,511 ounces), and Nevada (189,600 ounces), while Colorado shows a decrease of 133,830 ounces. Nevertheless, Colorado still heads the list of gold-producing States and Territories with a yearly production of 1,109,452 ounces, while Alaska is now a very close second, with 1,033,537 ounces. California is third, with 911,041 ounces. The total production of silver in 1906 was 56,517,900 fine ounces, valued at $38,256,400, an increase of 416,300 ounces over 1905. The largest in-

crease was in Utah (increase 1,188,200 ounces) and Idaho (710,600 ounces), while Montana shows a loss of 914,400 ounces, Nevada of 655,900 ounces, and Colorado of 495,400 ounces. The chief silver producer is still Montana, with a yearly production of 12,540,300 ounces. Colorado is second, with 12,447,400 ounces. Utah is third, with 11,508,000 ounces. The complete figures may be found in an advance chapter from *Mineral Resources*, by Waldemar Lindgren, on the production of gold and silver in 1900.

Sand-Lime Brick.—The manufacture of sand-lime brick is rapidly becoming an important industry in the United States and is likely to be as profitable here as it has been in Germany for the last ten years. A sand-lime brick is essentially a mass of sand cemented by hydrous lime silicates. The bricks can easily be made with a crushing strength of over 4,000 pounds per square inch, exceeding in this respect some sand-stones, and a tensile strength of over 200 pounds per square inch, and they withstand severe freezing, thawing and fire tests. When made with pure sand their color is white, but by the addition of manganese or graphite in varying proportions, gray or pink brick may be produced. Both common and front bricks are made. Their chief merits seem to be their white color and their somewhat lower cost of manufacture than that of clay or shale bricks used for building fronts and for ornamental purposes. It is claimed that they make rigid structures and that they are in every way safe and satisfactory as building material. A brick plant for making sand lime bricks, near Sayreton, a village just north of Birmingham, Ala., is briefly described in a paper by Charles Butts in the annual economic bulletin (No. 315) of the United States Geological Survey for the year 1906. The paper includes a list of publications dealing with the subject of sand-lime bricks.

Norwegian Water-Power and Foreign Capital.—The King of Norway has given his consent to the bill passed by the Storthing in relation to the utilization of water-power. It is provided under the new act that embankment and deepening of works for the regulation of a water course, even if the cession of soil and land that are not one's own is not required for the execution of the works, cannot be taken in hand without previously obtaining the consent of the King, as soon as the water-power used by the undertaking for industrial purposes is increased to at least 3,000 hp. During the proceedings in the Storthing, in respect of the regulation of the Miosen Lake—the largest in Norway—the Opposition to the Government did not conceal that in contesting the Government's decision they were materially concerned with rendering it as difficult as possible for foreign capital to "exploit" the rich water powers of the Glommen for industrial establishments. The Opposition even went so far as to accuse the Government of injuring the interests of the country for the advantage of foreign capitalists. Immediately on the day following the victory of the Government in the matter of the Miosen Lake scheme, the Opposition brought in a motion, which has now become law, by the giving of the King's assent, as already mentioned. This motion was adopted by the Storthing without noteworthy discussion, although it was opposed by the Government on the ground that the proposal represented a rupture of all traditional customs and an interference with private rights in property. But the Government itself had already embarked upon this path by having established the completely new principle for Norway that the natural riches of the country represent, in a certain measure State property, and that the State has the right of utilizing these riches for its advantage. It is recalled in this connection the fact that in the spring of this year a wealthy German company, which wished to acquire the whole occurrence of ore near Salangen, in Finmark, was compelled to pay 36,000 kronen ($9,000) to the State for the grant of the concession. In addition to this, a Swiss company obtained permission to utilize the water-power of the Kinserbach only on the express condition that the whole installation should revert to the State free of charge at the expiration of seventy-five years. The correspondent adds, that foreign capital scarcely runs the danger under the present ministry of being burdened "any more than necessary," but he predicts a bad time for foreign capitalists when the present Opposition should become the government of the day, and they are now preparing a plan of campaign with the object of securing the political control of the country.—(*London Electrical Review*, Oct. 4.)

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

Calcium Carbide (*Continued.*)

No. 601,367. March 29, 1898. C. L. Wilson, C. Muma, J. W. Unger, H. Schneckloth, A. P. Brosius and J. C. Kuchel.

Sticks of compressed lime and carbon are fed downward through (seven) holes in a vertical carbon electrode into an arc sprung to a disc electrode beneath. At the top of the upper electrode is a cylindrical insulating extension, also having holes for the sticks. When the current is weak, sticks may be fed through some but not all of the holes in the upper electrode. The smelting zone is inclosed by a two-part metal hood, which is movably supported by cables. The brick base and the metal sides of the hood are protected with a mass of pulverized carbide. As reduction proceeds the molten product accumulates on the pulverized carbide lining, and the upper electrode is gradually raised. At the finish the hood is raised and the mass of carbide on the brick base allowed to cool.

No. 609,864. Aug. 30, 1898. Matthew P. Wood.

Economizes electric current by preheating cylindrical blocks of a mixture of pulverized graphite or other form of carbon, lime and 1 to 3 per cent of a binder, *e. g.*, coal-tar, pitch, resin, asphaltum, molasses or sugar. A series of these blocks are fed vertically downward through holes in the roof and hearth of a Siemens regenerator furnace. The blocks are heated in this furnace by the combustion of gas to, say, 4,000° F., and an electric current is then passed through them, from carbon anodes lowered through the holes in the roof into contact with the upper ends of the hot blocks, thereby raising their temperature to from 5,000° F. to 6,300° F. The blocks are thus converted into molten calcium carbide, which is tapped out of the furnace hearth. Hydrocarbons may be supplied to the furnace chamber, to give an oxidizing or non-oxidizing flame, as desired. The fusion of the charge-blocks is said to begin at their tops, where they contact with the anodes, streams of molten carbide coursing down the blocks.

No. 629,394. July 25, 1899. Isaiah L. Roberts, N. Y. City.

Feeds charge through a square carbon chute onto a horizontal resistance grating of bars spaced apart one-eighth or one-quarter of an inch and removably supported in notches in the opposed ends of massive conductors. The spaces between the bars are initially filled by small pieces of carbon or coal. The produced carbid melts and drops through the spaces into a chamber below, closed by a transversely sliding gate. When the gate is opened the carbid falls into a vessel removably secured below. A pipe leads the carbonic-oxid gas from below the zone of reduction into the space above the receiving vessel, to displace air. The walls of the furnace consist of fire brick lined with compressed magnesia and surrounded by slaked lime or calcium magnesia and a sheet-iron casing. The leading-in conductors are surrounded with asbestos. Good contact with the resistance bars is effected by a paste of graphite and water. A carbon resistance-pan may be substituted for the bars. The furnace may be used for the reduction of sodium potassium or zinc, an iron resistance-pan being suitable. These metals volatilize and condense in the chamber below.

(*To be continued.*)

NEW BOOKS.

The Chemistry of Commerce.—A simple interpretation of some new chemistry in its relation to modern industry. By Robert Kennedy Duncan. 262 pages, 58 illustrations. Bound in cloth. Price, $2.00 net. New York: Harper & Brothers.

Papers and Addresses of the Ninth Annual Session of the American Mining Congress, 1906.—Containing portraits of the officers and directors of the American Mining Congress. 151 pages; paper cover. Denver, Col.: Office of the Secretary.

Zinc and Lead Annual.—Webb City, Carterville mining district. Edited by Jesse A. Zook and W. S. Baxter. 48 pages. Paper binding. Price, 10 cents. Joplin, Mo.: Zook & Baxter.

Traite de Chimie Analytique Qualitative Suivi de Tables Systematiques pour L'Analyse Minerale.—By Louis Duparc and Alfred Monnier. 374 pages; illustrated. Paper binding. Price, francs 6. (Retail price in New York, $1.50.) Geneve: Librairie Kundig.

Chemical Reagents, their Purity and Tests.—A new and improved text based on and replacing the latest edition of Krauch's *Die Prüfung der chemischen Reagentien aus Reinheit*. By E. Merck. Authorized translation by Henry Schenck. 250 pages. Bound in cloth. Price, $1.50 net. New York: D. Van Nostrand Co.

Practical Text-Book of Chemistry.—By John Dabney Palmer. 190 pages. Bound in cloth. Price, $1.00 net. New York: John Wiley & Sons.

The Microscopy of Technical Products.—By Dr. T. F. Hanausek. Revised by the author and translated by Andrew L. Winton with collaboration of Kate G. Barber, Ph. D. 471 pages; 270 illustrations. Bound in cloth. Price, $5.00 net. New York: John Wiley & Sons.

The Physiology of Alimentation.—By Dr. Martin H. Fischer. 348 pages; 30 illustrations. Bound in cloth. Price, $2.00 net. New York: John Wiley & Sons.

Clean Water and How to Get It.—By Allen Hazen. 178 pages. 14 full-page half-tone illustrations. Bound in cloth. Price, $1.50 net. New York: John Wiley & Sons.

The Interpretation of Gas Analysis.—By Woodbridge Hale Birchmore, Ph. D. Explicit directions for making deductions needed for utilizing information given by a chemist's report of an analysis of illuminating gas, in respect to the problems daily demanding solution in business life. 75 pages. Bound in cloth. Price, $1.25 net. New York: D. Van Nostrand Co.

Solubilities of Inorganic and Organic Substances.—Compiled by Atherton Seidell, Ph. D. A hand-book of the most reliable quantitative solubility determinations. 380 pages. Price, $3.00 net. New York: D. Van Nostrand Co.

The Elements of Physical Chemistry.—By Harry Clay Jones. Third edition revised and enlarged. 659 pages; illustrated. Price, $4.00. New York: Macmillan Co.

First Principles of Chemistry.—By Raymond B. Brownless, Robert W. Fuller and others. 425 pages; illustrated by tables and diagrams. Bound in cloth. Price, $1.25. Boston, Mass.: Bobst, Allyn & Bacon.

The Chemistry of Paints and Paint Vehicles.—By Clare H. Hall. 134 pages; illustrated. Bound in cloth. Price, $2.00 net. New York: D. Van Nostrand Co.

American Soaps, Candles and Glycerin.—A practical manual of modern methods of utilization of fats and oils in the manufacture of soap and candles and of the recovery of glycerin. By Leebert Lloyd Lamborn. 706 pages; illustrated. Bound in cloth. Price, $7.50 net. New York City: D. Van Nostrand Co.

Glue and Gelatine.—A practical treatise on the methods of testing and use. By R. Livingston Fernbach. 208 pages, illustrated. Bound in cloth. Price, $3.00 net. New York: D. Van Nostrand Co.

Harper's Electricity Book for Boys.—By Jos. H. Adams. With an explanation of electric light, heat, power and traction, by Jos. B. Baker, technical editor *United States Geological Survey*. 407 pages, numerous illustrations. Bound in cloth. Price, $1.75. New York: Harper & Brothers.

A Text Book of Electrical Engineering.—By Dr. Adolf Thomalen. Translated from the German by G. W. O. Howe. 464 pages; illustrated by diagrams. Bound in cloth. Price, $4.20 net. New York: Longmans, Green & Co.

Gas and Oil Engines and Gas Producers.—A treatise on the modern development of the internal combustion motor and efficient methods of fuel economy and power production. By Lionel S. Marks and S. S. Wyer. 142 pages; illustrated. Bound in cloth. Price, $1.00. Chicago, Ill.: American School of Correspondence.

Steam Boilers, Their Theory and Design.—Third edition. By Harry de Berkeley. 394 pages; illustrated. Bound in cloth. Price, $4.00 net. New York: Longmans, Green & Co.

Advance chapters from Mineral Resources of the United States for 1906, Washington, D. C., United States Geological Survey:

The Production of Manganese Ores in 1906.—By Edwin C. Eckel. 11 pages.

The Production of Antimony, Arsenic, Bismuth and Selenium in 1906.—By Frank L. Hess. 16 pages.

The Production of Graphite in 1906.—By George Otis Smith. 7 pages.

The Production of Nickel, Cobalt, Tungsten, Vanadium, Molybdenum, Titanium, Uranium and Tantalum in 1906.—By Frank L. Hess. 26 pages.

The Production of Coal in 1906.—By Edward W. Parker. 195 pages.

Statistics of the Clay-Working Industries in the United States in 1906.—By Jefferson Middleton. 55 pages.

The Manufacture of Coke in 1906.—By Edward W. Parker. 59 pages.

BOOK REVIEWS.

Kurzes Lehrbuch der Organischen Chemie.—By William A. Noyes, professor of chemistry at the University of Illinois. Authorized German translation by Walter Ostwald. With a preface by Prof. Wilhelm Ostwald. 722 pages; illustrated. Leipzig: Akademische Verlagsgesellschaft m. b. H.

It is a significant fact that the work of American chemists attracts a steadily increasing interest in Germany.

The text book on organic chemistry by Prof. William A. Noyes, which here appears in German translation, is so well known to American chemists that it is unnecessary to explain its scope and character. But it will certainly be of interest to quote the preface by Prof. Wilhelm Ostwald in free translation:

"This addition of another book—the translation of an American text book—to the exceedingly long list of German treatises on organic chemistry is justified by the great independence and originality shown by the author in conceiving and solving his task. In view of the immense accumulation of isolated facts relating to organic chemistry, it is of decisive importance for the beginner to gain command as early and as thoroughly as possible of the outlines of the system which connects these facts. By an original arrangement of the material, the author has indeed succeeded in attaining such a symmetry and such a clear view over the whole subject that the student, after having mastered this little book, may continue his studies in full confidence that he can no longer get lost in the forest of organic chemistry. It is especially noteworthy that the author has succeeded in solving the difficult problem of bringing clearly before the student the vast fields to be mastered later on without discouraging him. The foundation of the author's success is his great clearness of explanation, which makes the student feel at home in the field cov-

ered in the book, and thus gives him the confidence of also mastering the rest. I may add that the modern achievements of general chemistry have found full consideration; this explains the writer's personal interest in this work." This preface is signed by Ostwald from his cottage "Energy" in Gross-Bothen. The translation into German appears to be excellent—the translator being evidently Prof. Ostwald's son. Prof. Noyes has himself made some additions to the text. There is a very full index of 36 pages.

* * * * *

Annuaire Universel des Mines et de la Metallurgie. By Robert Pitaval. 348 pages, with several maps. Paris: Société des Publications Scientifiques et Industrielles.

This new French yearbook is essentially a collection of addresses of mining and metallurgical companies, arranged according to countries and each country being sub-divided according to products, coal, iron, etc. Occasionally a very short indication is given of the equipment of the works, but such indications are too few and too brief to be of value. However, when nothing is desired but a list of names of companies producing a certain product in a certain country, this annual would be useful.

The following countries are covered in the book: France, Algeria, Tunis, Madagascar, New Caledonia, Tonkin, Belgium, England, Germany, Luxemburg, Austria, Hungary, Holland, Italy, Servia, Bulgaria, Bosnia, Herzegovina, Greece, Turkey, Sweden, Norway, Denmark, Russia, Spain, Portugal, United States, Mexico, Chili, Peru, Bolivia, Brazil, Argentine, Venezuela, Costa Rica, Cuba, Ecuador, Japan, Canada, South Africa, Transvaal, India, Australia, New Zealand.

There are numerous misprints in the names, but none of those we found were so bad as to make an address useless. As introduction a vocabulary of the principal terms in iron and steel metallurgy is given in eight different languages, according to the definitions of the Association for Testing Materials.

* * * * *

Introduction to Metallurgical Chemistry. For technical students. By J. H. Stansbie, B. Sc., F. I. C., Associate of Mason University College and lecturer in the Birmingham Municipal Technical School. Second edition. 252 pages; illustrated. Price, $1.25 net. New York: Longmans, Green & Co.

This little book is intended to be used in evening schools in preparatory courses, teaching the principles of chemistry in their application to metallurgy.

The plan of this book is simple. "It assumes that those who use it are practically interested in the common metals, and that they have no further knowledge of their properties than has been obtained by ordinary observation in a workshop or foundry, so that it is necessary to commence their scientific treatment at the very beginning. The physical properties of the metals and their alloys being fully treated in standard works on metallurgy, more than a passing notice is not devoted to this very important part of the study of metals. Brief references to the more useful properties will be found in different parts of the text. The greater portions of the chapters are taken up with a description of the chemical properties of the common metals, and in the development of chemical principles the metals are made to take as prominent a part as possible. The non-metals are, for the purpose of this book, regarded more as the servants of the metals than as their masters; but this is not from any want of appreciation of their importance, and it is hoped that the common ones are sufficiently described to make them quite familiar."

The book is mainly of a practical nature, so that the theoretical principles are taught by developing them from experiments, either from lecture demonstrations or from experiments made by the students themselves. Thus, the effects of air and water on metals are first studied. This is followed by a dis-

THREE NEW BOOKS

12mo, Cloth *498 Pages* *Price, $2.50 Net*

VAN NOSTRAND'S

Chemical Annual

A Hand-Book of Useful Data for Analytical, Manufacturing and Investigating Chemists, and Chemical Students, Based on Biedermanns' "Chemiker Kalender"

Edited by Prof. J. C. OLSEN, A.M., Ph.D

Polytechnic Institute, Brooklyn; Formerly Fellow Johns-Hopkins University; Author of "Quantitative Chemical Analysis, by Gravimetric, Electrolytic, Volumetric and Gasometric Methods."

With the Co-operation of Eminent Chemists

First Year of Issue, 1907

The absence of a comprehensive reference book of numerical data of the Science, has induced the publishers to undertake the publication of this Annual, which it is their intention to issue, *with new data, added annually.*

8vo, Cloth *250 Pages* *Price, $1.50 Net*

Chemical Reagents, Their Purity *and* Tests

A New and Improved Text Based on and Replacing the Latest Edition of KRAUCH'S

"Die Prüfung Der Chemischen Reagentien Auf Reinheit"

By E. MERCK

Authorized Translation by Henry Schenck, A.B. (Harvard)

This Book supplies a pressing need of an authoritative, practical standard, having successfully withstood years of use by both manufacturers and consumers.

Translation entirely rewritten, and much obsolete matter of previous editions omitted. The typographical arrangement is very plain, the salient points of any Reagent appearing at a glance. The exact conditions of each test have been laid down, and limitations and definitions have been given for many hitherto uncertain expressions, such, for example, as "unweightable residue." References are given, first to the original articles, then to abstracts of those articles in standard English publications.

Logarithms, factors for calculations, synonyms, atomic and molecular weights, etc., have been incorporated in the text.

8vo, Cloth *167 Pages* *Price, $2.50 Net*

Fuel, Water *and* Gas Analysis

For Steam Users

By JOHN B. C. KERSHAW, F.C.I.

"Author of Smoke Prevention"

With 50 Illustrations

CONTENTS

Fuels: Origin. Physical and Chemical Characteristics of Wood, Peat, Lignite, Bituminous Coal, Semi-Anthracite, Anthracite, Coke. Liquid Fuels. Briquette Fuels. Sampling. Apparatus for Analysis. Special Tests. Apparatus and Methods for Calorific Valuation. Practical Applications of Test Results.

Water: Sources. Physical and Chemical Characteristics of Well Waters, River Waters, Surface Waters and Rain Water. Apparatus and Methods for Analysis. Special Tests for Oil. Practical Applications of Tests Results. Use of Softening Apparatus and Reagents.

Waste Gases: Physical and Chemical Characteristics of Waste Gases. Collecting Gas Samples. Apparatus and Methods for Analysis. Applications and Use of Continuous and Recording Gas-testing Apparatus. Practical Applications of Gas Test Results.

Appendix: Rules for Sampling Fuel. Formula Calculating the Calorific Value. Use of Fuels of Low Calorific Value. Typical Tests of Exit Gases, etc. Index.

D. VAN NOSTRAND COMPANY

Publishers and Booksellers

23 Murray and 27 Warren Sts., New York

Just Ready

Electro Analysis

By EDGAR F. SMITH, M.A., Ph.D., Sc.D.
Professor of Chemistry, University of Pennsylvania

Fourth Edition, very completely Revised and greatly Enlarged and Improved. With 42 Illustrations. Octavo; 346 pages. Limp Leather. $2.50 *net*.

Synopsis of Contents

Introduction.—Sources of Electric Current: *Magneto-Electric Machines, Dynamos, Thermophile, Storage Cells.*—Reduction of the Current: *Rheostats, Resistance Frame.*—Measuring Currents: *Voltameter, Amperemeter, an Electro-Chemical Laboratory.*—Historical Sketch.—Theoretical Considerations. Rapid Precipitation of Metals in the Electrolytic Way.—Use of Mercury Cathode.—Determination of Metals.—Separation of Metals.—Additional Remarks on Metal Separations. Determination of the Halogens in the Electrolytic Way.—Determination of Nitric Acid in the Electrolytic Way.—Special Application of the Rotating Anode and Mercury Cathode in Analysis.—Oxidations by Means of the Electric Current.—The Combustion of Organic Compounds.—Index.

Descriptive Circular sent free upon request

P. BLAKISTON'S SON & CO.
Publishers of Books on Technology, Chemistry, Biology, Pharmacy, Medicine
1012 Walnut Street Philadelphia

Catechism on Producer Gas

By SAMUEL S. WYER, M. E.

An Elementary Treatise in Question and Answer form, containing 287 Questions and Answers

Fifty Pages. Illustrated. Pocket Size, price, $1.00, net

TABLE OF CONTENTS

I.—Fundamental Definitions
II.—Producer Gas and Its Manufacture
III.—History and Status of Producer Gas
IV.—Uses of Producer Gas
V.—Cleaning of Producer Gas
VI.—Handling of Gas Producers
VII.—Construction of Gas Producers

Sent anywhere on receipt of price

McGRAW PUBLISHING COMPANY
239 West 39th Street NEW YORK

Iron and Steel Magazine

We offer a limited number of back copies of the Iron and Steel Magazine at the following prices:

UNBOUND

Vol. VII.—Jan. to June, 1904
Vol. VIII.—July to Dec., 1904
Vol. IX.—Jan. to June, 1905
Vol. X.—July to Dec., 1905
Vol. XI.—Jan. to June, 1906
} $2.50 per Volume.

BOUND

In cloth (green),
Vols. VII. to XI., at $3 50 per Volume

ELECTROCHEMICAL PUBLISHING COMPANY
239 West 39th Street, NEW YORK

cussion of the common properties of matter. In dealing with the relation between metals and sulphur, the opportunity is taken of introducing the preparation and properties of sulphuric acid. This is followed by a description of the nature and occurrence of common salts and saltpetre, from which, with the aid of sulphuric acid, the other common acids are prepared. By the aid of these compounds common substances of importance in the treatment of metals are prepared and described.

Special attention is paid to the reaction between metals and acids, and the chemical equivalents of some metals and non-metals, together with their atomic weights, are considered at some length. The great importance of carbon in the treatment of metals is recognized and its properties carefully described. This chapter is followed by others in which the important subjects of combustion and reduction are somewhat fully considered. The pronounced part played by silicon and its compounds in metallurgical work is also specially recognized.

Different instructors will, of course, differ in the selection of the subjects to be emphasized in such an elementary course. But it would seem that the author has been quite successful in this respect. The beginner who masters the contents of this book will have laid a good and solid foundation.

* * * * *

FOODS AND THEIR ADULTERATION. Origin, manufacture and composition of food products, description of common adulterations, food standards and national food laws and regulations. By Harvey W. Wiley, M. D., Ph. D. 1,625 pages, with 11 colored plates and 80 other illustrations. Price, $4.00 net. Philadelphia: P. Blakiston's Son & Co.

During the past years the Department of Agriculture in Washington has been in the limelight of public interest on account of its extensive activity in various directions and especially on account of the crusade started by Dr. Wiley as chief of the Bureau of Chemistry of the Department against adulterations of foods and beverages. For this reason this book of Dr. Wiley will certainly attract general attention.

It is a heavy and imposing volume with some pretty colored plates and a great many instructive illustrations. There are ten chapters, dealing respectively with meats and meat products; poultry and eggs and game birds; fish foods, milk and milk products and oleomargarine; cereal foods; vegetables, condiments, fruits; vegetable oils and fats and nuts; fungi as foods; sugar syrup confectionary and honey, infants' and invalids' foods. Four appendices deal with food standards and regulations.

The book is descriptive in character and has been "designed to interest the consumer as well as the manufacturer, the scientific as well as the general reader, all of whom it is hoped will find in it something useful. The consumer is entitled to know the nature of the product offered, the manufacturer and dealer the best methods of preparation. It will give the physician and sanitarian knowledge of the value of foods, their proper use and inspection, and, while not analytical in purpose, will provide the chemist with information which will guide him in his work of detecting impurities."

* * * *

HARPER'S ELECTRICITY BOOK FOR BOYS. Written and illustrated by Joseph H. Adams. With an explanation of electric light, heat, power and traction by Joseph B. Baker, and a dictionary of electrical terms. 307 pages, illustrated. Price, $0.75. New York: Harper & Brothers.

ELECTROCHEMICAL AND METALLURGICAL INDUSTRY has emphasized editorially more than once the importance of manual training schools for the future of our industries. It may not be amiss to point out here that manual training should really begin at home. The latest volume of the Transactions of the American Foundrymen's Association contains the following remarks by its distinguished secretary, Dr. Richard Moldenke, on the production of our future mechanics, molders, etc.:

The average American boy is a born mechanic, but he seldom has his natural gifts in that direction properly developed. The writer once served on his local school board, and took pains to familiarize himself with the practical value to the community of the three R's as taught in the little school houses at the cross-roads in the farming districts of his State. He helped to inaugurate a kindergarten in one school a mile and a half from his home, and at that time sent his two little boys there daily. These two American boys had had the run of the tool shed, nail-box, etc., ever since they were big enough to walk, and if a wood-chisel was afterwards found badly nicked, or a good piece of board filled with nails, it was charged to profit and loss in the development of their inventive and mechanical faculties. It was interesting to note the mental progress of these boys after they had attended the kindergarten a while. The nails were now driven into boards into geometric figures, and after their hides (the boys') had been warmed sufficiently on occasion, the good boards were left alone and scrap substituted. But now appeared fearfully and wonderfully constructed bridges over little brooks, the joints of pin construction, and they could stand a load. This shows that the mechanical turn to a boy's mind can nicely be brought out by proper instruction, even in play, and to-day these two shavers, respectively 8 and 10 years old, help their father in his experimental foundry in the cellar, keeping the 'bot-sticks primed, skimming the ladles, watching the power, and they do not get rattled when some metal slops over on a wet concrete floor. Our American boy wants as much of this as he can get without interfering with the necessary studies."

"Harper's Electricity Book for Boys" should be valuable just for such purposes. It is a kindergarten method of giving a first instruction in electrical engineering. The book should be a nice Christmas gift for bright boys.

The first part contains six chapters with the headings: some general explanations; cells and batteries; push-buttons and switches; magnets and induction coils, annunciators and bells; current detectors and galvanometers. The second part contains nine chapters: electric resistance; the telephone; line and wireless telegraphy; dynamos and motors; galvanism and electroplating; miscellaneous apparatus (a rotary glass-cutter, a mouse-killer, etc.); frictional electricity; prescriptions (cement, insulators, etc.); electric light, heat and power.

* * * * *

A Family Motor Tour Through Europe. By Leo Hendrik Baekeland. 366 pages; 182 illustrations. Price, $2.00. New York: *The Horseless Age.*

Dr. Baekeland is best known to the general public—at least as far as photographers are concerned; and who is not an amateur in our days?—as the inventor of velox paper. Electrochemists appreciate greatly his engineering work in bringing the Townsend cell to operation on a commercial scale in Niagara Falls for the production of caustic soda and chlorine. But when Dr. Baekeland was elected three years ago the president of the Chemists' Club by his professional friends in New York, they showed that they admired not only his scientific and engineering achievements but the man as man.

This book, telling the story of his automobile trip through England, Scotland, France and Italy, made in the summer of 1906, with his wife and two children, is a charming human document. It is profusely illustrated with reproductions of photographs taken on the tour. "I know of more than one person who, after devoting his life almost exclusively to the art of making money, suddenly discovers on the day when he undertakes a vacation trip that he has forgotten the art of enjoying life." Certainly, Dr. Baekeland does not belong to this class so very abundant in this country. To him touring is not only an agreeable pastime, but a great intellectual enjoyment; and this enjoyment will be shared by the readers of his book, since his characteristic pen and camera sketches reveal the mind of a scientist combined with the heart of an artist.

HASKINS-MACLEOD—*Organic Chemistry,* including certain portions of Physical Chemistry, for Medical, Pharmaceutical, and Biological Students. With Practical Exercises. 12mo, xi+367 pages, 24 figures. Cloth, $2.00 net.

HINDS—*Chemistry by Observation, Experiment, and Induction.* A Laboratory Manual for Students. Second Edition, Revised and Enlarged. 12mo, vi+349 pages, 56 figures. Cloth, $1.00 net.

HOLLEMAN-WALKER-MOTT—*A Text-book of Organic Chemistry.* Second English Edition, Rewritten. 8vo, xviii+589 pages, 83 figures. Cloth, $2.50.

DANNEEL-MERRIAM—*Electrochemistry.* Theoretical Electrochemistry and its Physico-chemical Foundations. 12mo, vii+181 pages, 18 figures. Cloth, $1.25 net.

ABEGG-VON ENDE—*The Electrolytic Dissociation Theory.* 12mo, vii+180 pages. Cloth, $1.25 net.

JOHN WILEY & SONS
43 and 45 E. 19th St. New York City

Eleventh Edition

Metallurgy of Cast Iron

A complete exposition of the processes involved in its treatment, chemically and physically, from the blast furnace through the foundry to the testing machine, being a practical compilation of original research.

By THOMAS D. WEST

Contents

PART I.—Manufacture and Use of Coke—Properties in Ores—Operations of Blast Furnaces—The Different Brands of Pig-Iron and How to Purchase and Use Them Intelligently (27 chapters). II.—Elements in Cast-Iron and Their Physical Effect—Utility of Chemical Analyses and How to Use Them in Making the Different Mixtures of Irons Used in Making Gray and Chilled Castings (21 chapters). III.—Properties of and Methods for Testing Molten Iron—Phenomena in the Actions of Cooling Metal, etc.—Results of Tests in All Kinds of Irons—Best Methods for Testing (23 chapters). APPENDIX. Selected Tables for Use in Furnace and Foundry Work.

Cloth 638 Pages 153 Illustrations Price, $3.00 net

Sent Anywhere, postpaid, for the Price by the

McGRAW PUBLISHING COMPANY

239 West 39th Street :: New York

TN
1
C45
v.5

Chemical engineering

Physical &
Applied Sci.
Serials

PLEASE DO NOT REMOVE
CARDS OR SLIPS FROM THIS POCKET

UNIVERSITY OF TORONTO LIBRARY

ENGIN STORAGE